Advanced course (FME 071): Analytical mechanics

HT LP1, 2004. The course is optional. Credits: 5.

Course literature: Hand out material (Lecture notes, exercises, examination tasks).
Goldstein, Poole & Safko; Classical Mechanics, 3rd ed., Addison Wesley, 2002.

Teacher: Ass. Prof. Per Lidström (Lectures 1-19, exercises, course coordination)
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Dr. Stefan Keppeler, Mathematical Physics (Lectures 20 and 21).

Schedule:	**Lectures:**	**Mond. 13-15**	**Tuesd. 13-15**	**Wednesd. 15-17**	
	Exercises:				**Thursd. 15-17**

Room: Dept. Library, M-building, 2nd floor.

Weekly curriculum (Preliminary):		Sections in Goldstein Poole & Safko
w.1 (30 aug-3 sept)		
Lecture 1:	Course objective. Examination. Introduction. The equations of motion in classical mechanics: Newton´s and Euler´s equations.	
Lecture 2:	The equations of motion in classical mechanics: External and internal forces. Constraints. d`Alembert´s principle.	1.1-1.3
Lecture 3:	Lagrange´s method: Generalized coordinates. Kinetic energy. Generalized forces.	1.4
Exercise 1:		
w.2 (6-10 sept)		
Lecture 4:	Lagrange´s method: Lagrange´s equations. Conservative forces. Potential. Lagrangian function.	1.5
Lecture 5:	Variational methods. Euler-Lagrange´s equations.	2.1-2.5
Lecture 6:	Lagrange´s method: Constants of motion. Symmetry. Noether´s theorem.	2.6-2.7
Exercise 2:		
w.3 (13-17 sept)		
Lecture 7:	Lagrange´s method: Invariance properties. Gauge tansformation.	
Lecture 8:	Lagrange´s method: Applications.	
Lecture 9:	Hamilton´s method: Canonical momenta. Phase space. Legendre-transformation. Hamiltonian function. Hamilton´s equations.	8.1
Exercise 3:		
w.4 (20-24 sept)		
Lecture 10:	Hamiltonian dynamics: Flow in phase space. Liouville´s theorem. Cyclic coordinates. Constants of motion.	8.2
Lecture 11:	Hamilton´s method: Variational principles.	8.5-8.6
Lecture 12:	Hamiltonian dynamics: Canonical transformations.	9.1-9.3
Exercise 4:		
w.5 (27 sept-1 oct)		
Lecture 13:	The brackets of Poisson and Lagrange.	9.5
Lecture 14:	Hamiltonian dynamics: Transformation theory. Integral invariants. Symplectic geometry.	9.4, 9.6-9.8
Lecture 15:	Hamilton-Jacobi´s method. Genererating function.	10.1-10.4
Exercise 5:		

w.6	(4-8 oct)		
	Lecture 16:	Integrable systems. Action-angle variables. Periodic and quasiperiodic motions. KAM.	10.5, 10.8, 11.1-11.2
	Lecture 17:	Perturbation theory. Averaging. Adiabatic invariants.	12.1-12.5
	Lecture 18:	Introduction to deterministic chaos.	11.3-11.9
	Exercise 6:		
w.7	(11-15 oct)		
	Lecture 19:	Lagrange´s och Hamilton´s methods in continuum mechanics and field theory.	13.1-13.4, 13.7
	Lecture 20:	Introduction to Wigner-Weyl calculus - Quantum mechanics on phase space: Weyl quantisation, Wigner function and Weyl symbols.	
	Lecture 21:	Quantum to classical asymptotics: Moyal product, classical and quantum time evolution, Egorov theorem.	
	Exercise 7:		

Course objectives:
The objectives of this course are to present the principles and methods of analytical mechanics based on Lagrange´s and Hamilton´s formulations of the laws of classical mechanics, and, to give a theoretical basis for further studies in classical and quantum mechanics.

Course contents:
1) Topics presented at lectures and in the lecture notes.
2) Topics in Goldstein, Poole & Safko; Classical mechanics, 3rd ed. Addison Wesley, 2002, given in the curriculum above.

The scope of the course is defined by the curriculum above and the lecture notes (”Lecture notes on Analytical Mechanics”). These notes will be handed out during the course. As an alternative (or complement) to the lecture notes the student may wish to consult the sections in Goldstein Poole & Safko given in the curriculum above.

The teaching consists of Lectures and Exercises:
Lectures: Lectures will present the topics of the course in accordance with the curriculum presented above.
Exercises: Problems for the Exercises will be handed out on a weekly basis and the student is recommended to work out these tasks. At each Exercise occasion solution methods are presented by the teacher on the white board. Problems not considered at the Exercises may be regarded as homework.

Examination:
Examination by hand in solutions to 5 examination tasks. The examination tasks will be handed out starting end of w. 2.

To pass (with credit 3) it is required:

that (hand in) solutions to all 5 examination tasks (with subtasks) are presented and that at least 4 of the 5 examination tasks (or 80%) have been correctly solved. If all examination tasks are correctly solved the credit is 4.

To get credit 5 an oral examination is required. The task of the oral examination will be to present and discuss a specified topic in Analytical Mechanics. The topic (and text material) for the oral examination will be individually given.

Final date for examination tasks Friday, October 15th

Per Lidström
Division of Mechanics