

**Theory of lab-on-a-chip systems (33241)
course plan and exercises 2009**

Date	Lecture topic and textbook sections to read	Exercises
01 Sep	Basic concepts in microfluidics (Secs. 1.1, 1.2, 1.3, 1.4). Lab-on-a-chip intro. Fluids, liquids and gases. The continuum hypothesis. Continuum fields. The index notation.	1.1, 1.2, 1.3, 1.4, 2.1, 2.2
08 Sep	Governing equations (Secs. 2.1, 2.2, 3.1). The continuity equation. Pressure and body forces, the viscous stress tensor. Deriving the Navier-Stokes equation. Reynolds number Re . Fluids in mechanical equilibrium.	2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 3.1, 3.2
15 Sep	Basic flow solutions (Secs. 3.3, 3.4, 3.7). Couette flow, Poiseuille flows in elliptical, circular, triangular, and rectangular cross sections. Flow rate. A sphere in a steady flow.	3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.10, 3.11, 3.12, 3.14
22 Sep	Hydraulic resistance and compliance (Secs. 4.1, 4.2, 4.5, 4.6, 4.7). Compliance, equivalent circuit theory for microfluidic networks. Random walk models of diffusion. The Péclet number Pe .	4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.10
29 Sep	Diffusion, basics (Secs. 5.1, 5.2, 5.3). Random walk models. Deriving the convection-diffusion equation. Solving the diffusion equation in 1D, 2D and 3D.	5.1, 5.2, 5.3, 5.4
06 Oct	Diffusion, molecular separation (Secs. 5.4, 5.5.1., 5.5.2). Molecular separation by a lab-on-a-chip device: the H-filter. Taylor dispersion.	5.5, 5.6, 5.7, 5.8
13 Oct	Fall break	
20 Oct	Time-dependent flow (Secs. 6.1, 6.2, 6.4). Starting a Couette flow. Stopping a Poiseuille flow. Accelerated spheres and Stokes drag.	6.2, 6.3
27 Oct	Capillary effects (Secs. 7.1, 7.2, 7.3, 7.4). Pressure drops across interfaces and the Young-Laplace equation. Contact angles and the Young equation. Capillary rise. Capillary pump. Bond number Bo .	7.1, 7.2, 7.4, 7.5, 7.9, 7.10, 7.11
03 Nov	Electrohydrodynamics (Secs. 8.1, 8.2, 8.3). Electric screening. Surface charges. The Poisson-Boltzmann equation and the Debye-Hückel approximation.	8.1, 8.4, 8.5, 8.6, 8.7
10 Nov	Electroosmosis (EO) (Secs. 9.1, 9.2, 9.4, 9.5, 9.6). Navier-Stokes and Poisson equations. EHD transport theory and the Nernst-Planck equation. EO: mobility, velocity, pressure and flow rate. EO pumps.	9.1, 9.2, 9.4, 9.5, 9.6
17 Nov	DC dielectrophoresis (DEP) (Secs. 10.1 - 10.5). Introduction: dipole moments, polarization, dielectric constants, the gradient force. Dielectric spheres and dc DEP in dielectric media.	9.7, 10.1, 10.2, 10.3, 10.4, 10.5
24 Nov	AC DEP and magnetophoresis (MAP) (Secs. 10.6 and 11.1+ Fig.11.4). Handling of suspensions and cells by ac DEP. Introduction to magnetophoresis. Magnetophoretic lab-on-a-chip systems.	10.6, 10.7, 10.8
01 Dec	Repetition. Preparation for the oral exam: Selected students present the six exam questions in class and get an evaluation.	
The oral exam is Wednesday 16 Dec and Thursday 17 Dec		