LUNDS TEKNISKA HÖGSKOLA
Lunds universitet



Course program: VVR 120, Fluid mechanics for W3, 2016.

Course responsible: Ronny Berndtsson, V-building, 3rd floor, room 3146, phone 2228986, email Ronny.Berndtsson@tvrl.lth.se.

Office hours: Course responsible is available during regular office hours.

Course structure: Lectures 38 hrs, tutorials 10 hrs, consulting time 14 hrs, and self-studies 138 hrs.

Teacher: Ronny Berndtsson (rob).

Course objectives are to give students basic knowledge in fluid mechanics required to analyze and solve water and energy related problems typical for environmental engineering. After the course, the students should be able to apply their knowledge in fluid mechanics to solve environmental and energy related problems in water resources, water management, and water supply.

Contents include fluid fundamentals: density, viscosity, and surface tension. Hydrostatics: relation pressure/density/level, hydrostatic force. Fundamentals of flow: stationary and nonstationary flow, streamlines, laminar/turbulent flow. Basic equations: continuity equation, energy equation, momentum equation. Engineering applications: pipe flow, pumps, and channels. Applications in natural systems: watercourses. Measuring methods include pressure, velocity, and flow.

Touching points with earlier courses: Engineering modeling; force, movement, and simple stationary flow. Hydrology and aquatic ecology; water courses/channel flow and groundwater flow. Mathematics; integrals and ordinary and partial differential equations. *Later courses*: Mass transport; advective and diffusive transport, turbulent diffusion, and interaction particle/fluid. General connection to advanced courses within water resources.

Student involvement: A course committee, with course responsible and student representatives, will meet approximately every second week (if necessary more often) to discuss course results.

Literature: 1) Hamill L., Understanding Hydraulics, 3^{d} ed., Palgrave, 2011 (main text book).
2) Malm J. and Larsson R., Examples for homework in fluid mechanics for environmental engineering students, Revised and improved version 2013.
3) Berndtsson, R., Handouts in fluid mechanics for environmental engineering students. Revised version 2016.

The literature is sold by KFS Studentbokhandel (John Ericsson Road 4; Studiecentrum).

Home page: On course home page lecture notes, dictionary, and example exams are found: http://www.tvrl.lth.se/utbildning/courses/vvr120/.

Tutorials and problems for homework: Appropriate preparation (individually solving tutorial exercises beforehand) and attendance (with active participation) in tutorials give 0.5 credit per 2 hrs tutorial (maximum 2.5 credits from 10 hrs tutorials). Consequently, 2.5 credits are possible to add to test and exam results. Students are expected to individually solve problems listed in the schedule as homework. Examples outside brackets indicate the most central problems to be solved. Course responsible is available 2 hrs per week according to schedule for problem consultation.

Exam: There are two alternatives for examination, 1) two written tests or 2) written exam. Open book is allowed in tests and exam: Main textbook, lecture handouts, and individual notes related to lectures (Examples for homework and solved examples from this are not allowed, thus, separate your lecture notes from your example notes!). Though, all solved examples from lectures are ok to bring to exam.
1) The first of the two written tests gives maximum 23.5 credits and covers hydrostatics and basic equations (lectures 1-9). Written test 1 is given 8:00-10:00, Monday 26 September in MA 8. Written test 2 gives maximum 34 credits and covers momentum equation, pipe flow, and channel flow (lectures 11-18). Written test 2 is given 14:00-17:00, Friday 28 October in Vic:3A-B. Maximum for the two written tests is 57.5 credits.
2) If result on the written test 1 was not so good it is possible to take the written exam. This is given 14:00-19:00, Friday 28 October in Vic:3A-B. The written exam covers all course contents and gives maximum 57.5 credits. Results from written exam have priority over results from written test 1. Note that results/solutions in tests and exam that are not structured, not clear, or not readable will result in point subtraction.

Grading: Maximum credits on the two written tests/exam plus above tutorials/guest lecture are 60 credits. To pass a minimum of 30 credits is necessary. 30 credits correspond to grade 3, 40 credits to grade 4, and 50 credits or higher correspond to the highest grade 5. Retake exam is given (pre-notification necessary) Thursday 22 December, 14-19 in V:N1 and 16 August 2017 8:00-13:00 in V:N2. Note that retake exam is not divided into two written tests and results at previous written tests/tutorials are not accounted for.

Course contents:
Lecture title (numbers within brackets correspond to suggested reading in Hamill)
Exercise no. refers to problems in the Example book and are meant as homework and training in individual problem solving.

1. Introduction, Fluid properties (1.1, handouts)
   - Introduction
   - Course structure
   - Fluid as continuous medium
   - Density
   - Compressibility
   - Exercise: A1
2. Fluid properties cont. (2.8, 4.1, handouts)
   - Viscosity
   - Surface tension, capillarity
   - Exercise: A2, A7, A9
3. Hydrostatics I (1.2-1.5)
   - Hydrostatic pressure, pressure-density-level
   - Pressure on plane surfaces
   - Exercise: B15, B17
4. Hydrostatics II (1.6-1.7)
   - Pressure on curved surfaces
   - Buoyancy / Archimedes principle
   - Exercise: B23, B27
5. Hydrostatics III (1.8, 2.1-2.7)
   - Hydrostatic equation
   - Pressure measurement, manometry
   - Exercise: B1, B3, B4, (B10)
6. Basic equations I (4.2-4.4)
   - Stationary and nonstationary flow, stream lines, stream tubes
   - One-, two-, and three-dimensional flow
   - Laminar and turbulent flow
   - Reynolds number
   - System and control volume
   - Continuity equation

- Exercise: C1, C2, C4, C7

7. Basic equations II (4.7-4.8)
- Bernoulli equation
- Kinetic energy, potential energy, and pressure energy for fluid in motion
- Energy level: velocity level, geometric level, and pressure level
- Bernoulli equation, applications
- Exercise: C12, C14, C23

8. Basic equations III (5.1-5.4)
- Pitot tube
- Vapor pressure, cavitation
- Equation for parabolic trajectory
- Bernoulli equation, applications
- Exercise: C26, C33, C40

9. Basic equations IV (5.1-5.4)
- Energy equation
- Pumps and turbines
- Flow with energy loss
- Energy and pressure levels
- Flow measurements
- Exercise: C34-35, C41

10. Summary, Lec 1-9, Written test 1
- Repetition of fluid properties, hydrostatics, and basic equations
- Solving typical exam problems at written test 1 (problem 6, 9, and 13 in exam leaflet)

11. Basic equations V (4.5-4.6)
- Momentum equation
- Applications - momentum equation
- Exercise: C43, C44

12. Basic equations VI (4.5-4.6)
- Applications - momentum equation
- Exercise: C54, C64

13. Pipe flow I (6.1-6.4, 6.6)
- Energy losses in pipe flow
- Local energy losses
- Pipes connected in series
- Exercise: D13, D14 (D15)

14. Pipe flow II (6.4, 7.1-7.4)
- Pipes connected in parallel
- Three reservoir problem
- Quasi-stationary pipe flow
- Exercise: D21, D26 (D27)

15. Pipe flow III (6.5)
- Laminar pipe flow
- Turbulence models
- Exercise: D1, D2, D4

16. Pipe flow IV (6.5)
- Smooth turbulent flow
- Rough turbulent flow
- Friction coefficient, Moody diagram
- Non-circular pipes
- Exercise: D8

17. Pipe flow V (11.5-11.7)
- Pump types
- Pump systems
- Pumps in series and in parallel
- Exercise: D35-36, D38

18. Channel flow (8.1-8.5)
- Introduction, definitions
- Laminar channel flow
- Uniform channel flow, Manning equation
- Exercise: E1-2

19. Summary, Lec 11-18, Written test 2
- Summary of course
- Solving typical written test 2 problems

SCHEDULE

Week	Date	Time	Room	Teacher	Class	Content
1/35	Mon 29 Aug	10-12	V:B	rob	Lecture 1: Introduction, fluid properties	
	Tue 30 Aug	10-12	V:B	rob	Lecture 2: Fluid properties, cont.	
	Problems for homework: A3, A8, A10-11 (A4)					
	Wed 31 Aug	8-10	KC:B	rob	Lecture 3: Hydrostatics I	
	-"-	13-15	V:3146	rob	Consultation: Problems for homework	
	Problems for homework: B16, B18, B20 (B19, B21-22)					
	Fri 2 Sep	10-12	V:R2	rob	Ex1 – Grp1	Fluid properties & Hydrostatics I
	-"-	13-15	-"-	rob	-"- – Grp2	-"-
2/36	Mon 5 Sep	10-12	V:B	rob	Lecture 4: Hydrostatics II	
	Tue 6 Sep	10-12	V:B	rob	Lecture 5: Hydrostatics III	
	Problems for homework: B24-25, B6, B8 (B26, B28, B5, B7, B9, B11-13, B2, B14)					
	Wed 7 Sep	10-12	V:B	rob	Lecture 6: Basic equations I	
	-"-	13-15	V:3146	rob	Consultation: Problems for homework	
	Problems for homework: C3, C9-10 (C5-6, C8, C11)					
	Fri 9 Sep	10-12	KC:H	rob	Ex2 – Grp2	Fluid properties & Hydrostatics II
	-"-	13-15	-"-	rob	-"- – Grp1	-"-
3/37	Mon 12 Sep	10-12	KC:C	rob	Lecture 7: Basic equations II	
	Tue 13 Sep	10-12	V:B	rob	Lecture 8: Basic equations III	
	Problems for homework: C15, C20, C22, C24, C25 (C13, C16-19, C21, C29-31)					
	Wed 14 Sep	8-10	V:B	rob	Lecture 9: Basic equations IV	
	-"-	13-15	V:3146	rob	Consultation: Problems for homework	
	Problems for homework: C27 C32, C36, C38, C42 (C37, C39)					
	Fri 16 Sep	10-12	V:R2	rob	Ex3 – Grp1	Basic equations
	-"-	13-15	-"-	rob	-"- – Grp2	-"-
4/38	Mon 19 Sep	10-12	KC:C	rob	Lecture 10: Repetition, Test 1 problems	
	Tue 20 Sep	10-12	V:B	rob	Lecture 11: Basic equations V	
	Wed 21 Sep	10-12	KC:B	rob	Lecture 12: Basic equations VI	
	-"-	13-15	V:3146	rob	Consultation: Test 1 Problems	
	Problems for homework: Test 1 problems					
	Fri 23 Sep	10-12	V:R2		Reserve	
	-"-	13-15	-"-		Reserve	
5/39	**Mon 26 Sep**	**08:00-10:00**	**MA:8**	**rob**	**WRITTEN TEST 1**	**Lecture 1-9; Fluid properties, Hydrostatics, Basic equations I-IV**
	Problems for homework: C45, C50, C53, C56, C65 (C46-49, C51-52, C46-49, C51-52, C55, C57-59, C60-63)					
	Wed 28 Sep	10-12	V:B	rob	Lecture 13: Pipe flow I	
	-"-	13-15	V:3146	rob	Consultation: Problems for homework	
	Problems for homework: D12, D17, D18 (D16)					
6/40	Mon 3 Oct	10-12	V:B	rob	Lecture 14: Pipe flow II	
	Problems for home work: D25, D28, D33 (D22-24)					
	Tue 4 Oct	8-10	V:B	rob	Lecture 15: Pipe flow III	
	Wed 5 Oct	8-10	V:B	rob	Lecture 16: Pipe flow IV	
	-"-	13-15	V:3146	rob	Consultation: Problems for homework	
	Fri 7 Oct	10-12	V:R2	rob	Ex4 – Grp2	Momentum eqn and pipe flow
	-"-	13-15	-"-	rob	-"- – Grp1	-"-

7/41	Mon 10 Oct	10-12	KC:C	rob	Lecture 17: Pipe flow V	
	Tue 11 Oct	10-12	V:B	rob	Lecture 18: Channel flow	
	Problems for home work: D3, D29, D11, D19, D20, D39 (D7, D5-6, D10, D37, D40-41)					
	Wed 12 Oct	10-12	V:B	rob	Lecture 19: Repetition, Written test 2 problems	
	-“-	13-15	V:3146	rob	Consultation: Problems for homework	
	Problems for home work: E3, E5, E7 (E4, E6, E8) and Test 2 problems					
	Fri 14 Oct	10-12	V:R2	rob	Ex5 – Grp1	Test 2 problems
	-“-	13-15	-“-	rob	-“- – Grp2	-“-
Test 2 and exam are given Friday 28 October, 14:00, in Vic:3A-B. Duration: 3 hrs (test 2; 14:00-17:00), 5 hrs (exam; 14:00-19:00).						