Ground Water (MHSE19)

**Yadav / Burghardt / Reimann/Alireza**

**Winter semester 2021 / 2022**

**Lectures (L) and Tutorials (T):**

**Thursday, 7:30 – 9:00 a.m. and 9:20 – 10:50 a.m., CHE 183/Online**

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| ***7:30 – 9:00*** | ***9:20 – 10:50*** |
|  | **October 14, 2021 (L1) 1 Yadav** |
| no lecture / tutorial | organizational aspects  What is hydrogeology?  groundwater as part of the global water  cycle, volume and mass budgets.  *Excel sheet/Jupyter notebook (JN) “decay”* |
| **October 21, 2021 (L2) 2 Yadav** | **October 21, 2021 (T1) 3 Yadav** |
| structure of the subsurface,  grain size distribution of unconsolidated  porous media, *Excel sheet/JN “sieve analysis”,* subterranean water | introduction to *Jupyter notebooks*, Python |
| **October 28, 2021 (L3) 4 Yadav** | **October 28, 2021 (T2) 5 Yadav** |
| groundwater and aquifers  pressure and pressure head  storage properties | aquifer storage properties,  homework problems 1, 2  *Jupyter notebooks* |
| **November 04, 2021 (L4) 6 Yadav** | **November 04, 2019 (T3) 7 Yadav** |
| Darcy’s law (1D)  hydraulic conductivity  intrinsic permeability  velocities, travel time and pore volume | Darcy’s law and intrinsic permeability  homework problems 3, 4  *Jupyter notebooks* |
| **November 11, 2021 (L5) 8 Yadav** | **November 11, 2021 (T4) 9 Yadav** |
| aquifer heterogeneity  layered systems, aquifer anisotropy  *Excel sheet/JN “Keff”* | aquifer heterogeneity and anisotropy  layered systems |
| **November 18, 2021 (L6) 10 Yadav** | **November 18, 2021 (T5) 11 Yadav** |
| steady-state groundwater flow in three  dimensions:  Darcy’s law in isotropic aquifers  streamlines and flow nets  isochrones and protection zones,  *Excel sheet/JN “uniform\_flow\_and\_well”*  Darcy’s law in anisotropic aquifers,  *Excel sheet/JN “anisotropic\_aquifer\_2D”* | solutions for homework problems 1 – 4  effective conductivity and flow nets  homework problems 5 – 7  *Jupyter notebooks* |

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| **November 25, 2021 (L7) 12 Yadav** | **November 25, 2021 (T6) 13 Yadav** |
| transmissivity, wells (overview)  groundwater flow near wells at steady  state, aquifer characterisation by  pumping tests,  *Excel sheet/JN “Theis”* | pumping test evaluation  homework problem 8  *Jupyter notebooks/ Excel Sheet* |
| **December 02, 2021 (L8) 14 Yadav** | **December 02, 2021 (L9) 15 Yadav** |
| conservative solute transport,  joint action of transport processes,  concentration profiles and breakthrough curves, *Excel sheet/JN-“advection\_dispersion\_1D”* | dispersive mass flow in 3D, summary  of sorption / desorption (equilibrium)  and degradation, joint action of  conservative transport and reactive  processes,  *Excel sheet/JN “transport\_1D”* |
| **December 09, 2021 (T7) 16 Yadav** | **December 09, 2021 (T8) 17 Yadav** |
| solutions of homework problems 5 – 8  sorption and degradation I  homework problems 9, 10  *Jupyter notebooks* | sorption and degradation II  homework problems 11, 12  *Jupyter notebooks* |
| **January 06, 2022 (L10) 18 Alireza/Yadav/Reimann** | **January 06, 2022 (T9) 19 Yadav** |
| Groundwater modelling I:  introduction incl. overview of types of  models / solution methods  example of a groundwater model  *Excel sheet/JN/ModelMuse-Modflow* | analytical solutions of transport problems  *Jupyter notebooks* |
| **January 13, 2022 (L11) 20 Alireza/Yadav/Reimann** | **January 13, 2022 (L12) 21 Alireza/Yadav/Reimann** |
| Groundwater modelling II:  FD method for 1D/2D groundwater flow,  *Excel sheets/JN “FD\_1D\_homogeneous” and*  *“FD\_1D\_heterogeneous”/ModelMuse-Modflow* | Groundwater modelling III:  functioning and relevant components of  iterative methods  successive over-relaxation incl. tests  *Excel sheet/JN/ModelMuse-Modflow* |
| **January 20, 2022 (L13) 22 Alireza/Yadav/Reimann** | **January 20, 2022 (T10) 23 Yadav** |
| Groundwater modelling IV:  Eulerian and Lagrangian approaches in  solute transport modelling  PT method incl. example  some remarks on FD methods to  simulate solute transport  *Excel sheet/JN/ModelMuse-Modflow* | solutions of homework problems 9 – 12  review & feedback  questions (e. g. concerning exam)  *Jupyter notebooks/Excel* |
| **January 27, 2022 (T11) 24**  **Alireza/Yadav / Reimann** | **January 27, 2022 (T12) 25**  **Alireza/Yadav / Reimann** |
| groundwater modelling with MODFLOW using MODELMUSE | |

**Summary:**

1. **13** Lectures (Slides, JUPYTER Notebook, Spreadsheet)
2. **12** Tutorials (using JUPYTER Notebook: 25 class problems, 12 Home-Work Problems, 1-set past exam solution, and 4-hours hands-on modelling with MODFLOW using MODELMUSE)
3. Online study material/self-study in interactive format: <https://prabhasyadav.github.io/iGW-I/intro.html>