**The University of Jordan**

**Faculty of Agriculture Department of Land, Water and Environment**

**Program: 2012-2013/Second semester**

**Water Resources and Management (604212)**

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| **Credit hours** | 3 | **Level** | Third or Fourth year | **Pre-requisite** |  |
| **Coordinator/ Lecturer** | Dr. Michel Rahbeh | **Office number** | 119 | **Office phone** | 22465 |
| **Course website** | http://www2.ju.edu.jo/sites/academic/m.rahbeh/default.aspx | **E-mail** | m.rahbeh@ju.edu.jo | **Place** | Room 106 |
| **Time** | 11:00 – 12:30 pm Mon, Wed |  |  |  |  |

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| **Office hours** | | | | | |
| **Day/Time** | **Sunday** | **Monday** | **Tuesday** | **Wednesday** | **Thursday** |
| **Day** | - | \* | - | \* | - |
| **Time** | - | 1.00 – 3.00 p.m | - | 1.00 -3.00 p.m | - |

**Course Description**

The course aim is to acquaint students with the concepts and tools of sustainable water management that can be applied to the quantitative and qualitative perspectives of water resources management. The course consists of six parts. The first part introduces the surface and ground waters as one continuum resource and the related sustainability concepts of water resources. The second part reviews the quantification of hydrological cycle in the context of watershed hydrological modeling. This part covers the stream flow routing through watersheds using Muskingum equation, and stream flow routing through reservoirs using the level pool routing methods. In the third part emphasizes

ground water physical parameters and the quantification of these parameters using pumping tests. This part also includes the discussion of the adverse effects of over pumping on confined and unconfined aquifers. The fourth part is reserved for the water quality parameters and related hazards, such as eutrophication, point and non-point pollution as well as the identification of non-conventional water resources. The fifth part, discusses the stochastic analysis of hydrological events such as determination of return periods, frequency analysis of extreme floods and calculation of droughts indices. The sixth a and final part, discusses reservoir management using the Linear Decision Rule (LDR).

**Learning Objectives**

* Perform quantitative hydrological analysis.
* Identify major water hazards.
* Demonstrate an understanding of the tools used in water management.

**Intended Learning Outcomes (ILOs):**

Successful completion of the course should lead to the following outcomes:

**A. Knowledge and Understanding:** Student is expected to

**A1.** Usewater resources literature

**A2.** Be familiar with the terminology commonly used in the hydrology literature

**A3.** Understand water quality guidelines

**A4.** Describe the concepts of Muskingum routing and level pool routing

**A5.** Understand the physical parameters of the ground water

**A6.** Understand and define eutrophication

**A7.** Differentiate between point and non-point pollution

**A8.** Understand the concepts of reservoir management

**A9.** Understand the basic hydraulics of pumping well

**B. Intellectual Analytical and Cognitive Skills:** Student is expected to

**B1.** Discuss the water resources sustainability concepts

**B2.** Discuss the relationship between water quality and quantity

**B3.** Discuss the effects of over pumping on the quantitative and qualitative sustainability of ground water

**B4.** Discuss concepts related to safe yield of aquifers

**C. Subject- Specific Skills:** Students is expected to

**C1**. Determine streamflow using watershed hydrological model

**C2.** Employ necessary methods (SCS-CN, synthetic unit hydrograph, unit hydrograph base flow separation) to determine runoff

**C3.** Determine groundwater recharge

**C4.** Estimate the groundwater physical parameters from pumping tests

**C5.** Route streamflow through watersheds and reservoirs

**C6.** Determine the parameters required for the level pool and Muskingum routing methods

**C7.** Determine drought indices

**C8**. Calculate a return period for a given hydrological event

**C9.**  Conduct frequency analysis of extreme floods

**D. Transferable Key Skills:** Students is expected to

**D1.** Devise a simplified watershed hydrological model

**D2.** Determine the appropriate releases from a small reservoir

**D3.** Suggest solutions to common water management challenges

# ILOs: Learning and Evaluation Methods

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| **ILO/s** | **Learning Methods** | **Evaluation Methods** |
| **A**. Knowledge and Understanding (**A1-A8**) | Term paper, Lectures, discussions and home works | Exams |
| **B**. Intellectual Analytical and Cognitive Skills (**B1-B4**) | Lectures, discussion and home works | Exams |
| **C**. Subject Specific Skills (**C1-C9**) | Lectures, discussion and home works | Exams |
| **D**. Transferable Key Skills (**D1-D3**) | Lectures, discussion and home works | Exams |

**Course Contents**

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| --- | --- | --- | --- |
| **No. of 1.5 hour lecture (s) /Week** | **Subject** | **Sources** | **ILOs** |
| **2 / 1st wk** | Part one:   * Sustainability concepts of water resources global and * local challenges * Water cycle and review of basic concepts * Surface and groundwater as one resource | EL. Nasar (2012), Northcliffe et al. (2008) | **A1, A2, B1** |
| **4/ 2nd, 3rd wk** | Part 2:  Review of quantification of the hydrological cycle:   * φ-index * Soil Conservation Services (SCS) method * Runoff generation * Streamflow hydrograph * Base flow separation * Derivation of the unit hydrograph * Construction of the synthetic unit hydrograph | Chow et al. (1988) (Chapters 3,4,5,6,7) | **A2, C1,C2** |
| **6/4th , 5th and 6th wk** | Part 2 (continued):   * Watershed hydrological modelling * Muskingum routing * Level pool routing | Chow et al. 1988 (Chapters 7,8 )  Song et al. (2011) | **A1, A2, A4, C1, C2, C3, C5,C6,D1** |
| **3/ 7th and 8th** | Part 3:   * Confined and unconfined aquifers * Transmissivity * Hydraulic conductivity * Porosity * Storage coefficient * Specific yield * Specific retention | Bear (1979) (Chapters 2, 4)  U.S. Army Corps of Engineers. (1999) | **A2,A5,B4** |
| **1/8th wk** | First Exam | 20/3/2013 |  |
| **4/9th and 10th** | Part 3 (cont’d):   * Dupuit assumption * Determination or of drawdown, radius of influence, hydraulic conductivity and transmissivity | Bear (1979)  (Chapters 4 and 8) | **A2, A5, A9, B4, C4** |
| **2/11th wk** | Part 3 (cont’d):  Adverse effect of over pumping:   * Groundwater salinization * Land subsidence * Sea water intrusion | Bear (1979) (Chapters 5,9) | **A2, B2, B3, B4** |
| **1/12th wk** | Part 4:  Water quality parameter  Eutrophication  Point and nonpoint pollution | Freeze and Cherry (1979) (Chaper 9)  Oram et al. (<http://www.wilkes.edu/water>)  USGS (http://toxics.usgs.gov/definitions/eutrophication.html) | **A1, A2, A3, A6, A7, B1, B2, D3** |
| **1/12th wk** | Second Exam | 20/4/2013 |  |
| **5/12,13, and 14 wk** | Part 5:   * Hydrologic statistics * Frequency analysis * Return period * Extreme events * drought | Chow et al. 1988 (Chapters 11 and 12) | **A2, C7, C8, C9, D3** |
| **2/15 th wk** | Part 6:   * Reservoir management * Linear Decision rule (LDR) | Revelle et al. (1969) | **A1, A2, A8 B1, D2,D3** |
| **wk 5th** | Term paper due |  |  |
| **16th wk** | Exam week | Final Exam as scheduled by the University registration |  |

**Learning Methodology**

# Question and answer teaching method will be used in this course; therefore, the students are encouraged to participate in classroom discussions. All study material will be circulated electronically, made available at the instructor’s website. The lectures will focus on comprehensive understanding of the course material and problem solving. The homework problem sets are designed to help the students to widen their understanding of the course material and practice their problem solving skills.

# Evaluation

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| **Evaluation** | **Point %** | **Date** |
| **First Exam** | 15 | 2/4/2014 |
| **Second Exam** | 15 | 7/5/2014 |
| **Term paper** | 10 | One week before final exams |
| **homework** | 10 | Homeworks will be assigned after each topic. |
| **Final Exam** | 50 | Exam week |

**Main Reference/s:**

1. Bear, J. 1979*. Hydraulics of ground water*. New York: McGraw Hill.
2. Chow, V. T., Maidment, D. R. and Mays, L. W. 1988. *Applied hydrology*. McGraw-Hill.
3. EL. Nasar, H. K. 2012. Jordan’s Precious Groundwater Resources.5th ACWUA best practice conference, Muscat, Oman.
4. Oram, B. Haslor, S., and Redmond, B. *Water quality*. Last retrieved April 13, 2014 from http://www.wilkes.edu/water.
5. Freeze, R. A. and Cherry J A. 1979. *Groundwater*. Prentice –Hall, Inc.
6. Nortcliff, S., Carr, G., Potter, R. and Darmame, K. 2008. Jordan’s Water Resources: Challenges for the future. Geographical paper No. 185, Reading, UK.
7. Revelle, C., Joeres, E. and Kirby, W. 1969. The linear decision rule in reservoir management and design . 1. Development of stochastic model, *Water Resources Research* 5(4): 767 – 777.
8. Song, X., Kong, F., and Zhu, Z. 2011. Application of Muskingum routing method with variable parameters in ungauges basin. *Water Science and Engineering 4(1): 1-12.*
9. U.S. Army Corps of Engineers. 1999. *Engineering and design : groundwater hydrology*. Washington D.C.
10. USGS. Eutrophication Last retrieved April 13, 2014 from http://toxics.usgs.gov/definitions/eutrophication.html

**Grading Scale**

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| From (%) | To (%) | Scale | Letter Grade | Result |
| 86 | 100 | 4 | A | Excellent |
| 83 | 85 | 3.75 | A- | Excellent |
| 80 | 82 | 3.5 | B+ | Very Good |
| 74 | 79 | 3.0 | B | Very Good |
| 71 | 73 | 2.75 | B- | Very Good |
| 68 | 70 | 2.5 | C+ | Good |
| 62 | 67 | 2.0 | C | Good |
| 59 | 61 | 1.75 | C- | Good |
| 56 | 58 | 1.25 | D+ | Accepted |
| 50 | 55 | 1.00 | D | Accepted |
| 36 | 49 | 0.75 | D- | Fail |
| 0 | 35 | 0 | F | Fail |

**Notes and class room policies**

* Regular and timely attendances are expected from all students. University regulations concerning class attendance will apply
* The students are expected to submit homeworks in due time, a late submission will result in 20% deduction of the homework grade and will not be accepted once the key answers are provided
* Exams absentees are allowed to write makeup exams only if an acceptable and documented excuse is provided; for example, a medical report. Makeup exams are usually more difficult than regular exams
* Zero tolerance for cheating and plagiarism
* For more details on University regulations please visit: <http://www.ju.edu.jo/rules/index.htm>