UNIVERSITY OF THE PUNJAB

NOTIFICATION

It is hereby notified that the Syndicate at its meeting held on 27-07-2023 has approved the recommendations of the Academic Council made at its meeting dated 24-05-2023regarding approval of the Revised Syllabi and Courses of Reading for M.Phil Applied Hydrology under Semester System at the College of Earth and Environmental Sciences w.e.f. the Academic Session, 2021 and onward.

The Revised Syllabi and Courses of Reading for M.Phil Applied Hydrology under Semester System is attached herewith as Annexure 'A'.

Sd/-
REGISTRAR

Admin. Block,
Quaid-i-Azam Campus,
Lahore.

No. D/ 7670 /Acad. **Dated: 11 – 10 /2023.**

Copy of the above is forwarded to the following for information and further necessary action: -

1. Dean, Faculty of Geo Sciences.
2. Principal, College of Earth and Environmental Sciences.
3. Controller of Examinations
4. Director, IT for placement at the website
5. Admin Officer (Statutes)
6. Secretary to the Vice-Chancellor.
7. PS to the Registrar.
8. Assistant Syllabus.

Assistant Registrar (Academic)
for Registrar

COLLEGE OF EARTH & ENVIRONMENTAL SCIENCES
UNIVERSITY OF THE PUNJAB

Revised Courses & Syllabi of
M.Phil. Applied Hydrology

1. Department Mission

The mission of the College is to groom the students into responsible and honest citizens and skilled professionals trained in their respective fields to serve the nation. Character building and moral training is an integral component of student-teacher relationship. student life in the College provides the students with all possible opportunities to acquire the most dynamic personalities with leadership qualities. Academically excellent and experienced faculty members are involved in teaching and research in the CEES. Classes are regularly held, well supplemented with laboratory work and observations in the field.

2. Introduction

The College of Earth and Environmental Sciences, University of the Punjab, Lahore is presently offering multidisciplinary degree program i.e. BS, M.Sc., MS, M.Phil. and Ph.D. degree programs in the disciplines of Environmental Sciences, Hydrology & Water Resources Management, Tourism & Hospitality Management, Geomatics and Occupational Health and Safety Management. The purpose of these courses is to produce graduates in these emerging disciplines with the insight and knowledge to serve the nation for attaining environmentally sustainable development in the country

Environmental changes, like desertification, silting of dam and reservoirs, water logging, salinity and contamination of land as well as surface and groundwater, have created lots of problems . Water is essential for life. The field of Hydrology and water resources management will have to continue to adapt to the current and future issues facing the allocation of water. With the growing uncertainties of global climate change and the long-term impacts of past management actions, this decision-making will be even more difficult. It is likely that ongoing changes will lead to situations that have not been encountered. As a result, alternative management strategies, including participatory approaches and adaptive capacity are increasingly being used to strengthen water decision-making.

Keeping in view the importance and the growing demands for training manpower in the emerging discipline, the College of Earth and Environmental Sciences has been established in the University of the Punjab in 2005. The new building of the College was completed in November 2008, featuring spacious rooms, moderately equipped laboratories, a library and large grounds.

3. Programme Introduction

Since the beginning of life on this planet water has vital significance and without it life seems impossible, therefore, it is essential to understand fundamental knowledge of hydrology & WRM. As the time passed human development has casted disastrous impacts on water resources arability in quantitative and qualitative context as well. Global warming, climate change, hydrological cycle changes, land, air and Sea level rising are the important issues of this century and these issues have significant effects on economy, society and environment. Therefore, it is need of the hour to develop a comprehensive plan to tackle these issues on priority basis. Keeping in view these issues and after getting an intensive feedback from society we have designed MPhil Applied Hydrology & Water Resources Management degree programme. This programme will consist of two years covering all key aspects of hydrology and water resources management. This will also provide an opportunity to younger generations to be skilled in field of hydrology and water resources. Since the industry is global and expanding with every passing day, it has twofold employment opportunities; local and international. The program will focus on optimal realization of the potential of students. This will also include training of students through soft skills, technology knowledge, work ethics, advancements in hydrology and to serve back to nation.

4. Programme Objectives

In order for our program to remain preeminent, our key goals are to:

1. To comprehend basic concepts of hydrology and water resources.
2. To evaluate and analyze hydrological systems and processes at a wide range of scales in both space and time for water resources assessment.
3. To design and conduct hydrological research and experiments for applied or scientific purposes.
4. To be able to perform hydrological computations to support engineering design of water resources schemes.
5. To use information and communication technology within a hydrological context.

5. Market need /rational of the Programme

Hydrology is an ancient profession which has also referenced in old testimony and ancient Chinese history. This field has been evolving with the passage of time and now it has grown to an independent field. In 15th century the aim was to build basic knowledge of water resources, with the start of 19th century water resources sustainable problems become dominant field of research. Now the major areas of hydrology are climate changes, global warming and water resources sustainability issues.

Pakistan has a youth bulge whereby about 60% youth of its total population is between the age bracket of 15 and 30 years, which indicates immense human resource potential of Pakistan. The Pakistan has numerous departments in which numbers of professionals already working and with the development of new projects further consumptions of hydrology professional will be prior task to these organizations. The WAPDA, Irrigation, PCRWR, Ministry of water resources, WASA, Academia and large numbers of private consultancies firms including NESPAK, NDC, MMP, ECSP, ACE, etc. will also hire our professionally trained students.

6. Admission eligibility criteria

- BS/M.Sc. Applied Hydrology & WRM / Geology with Specialization in Engineering Geology or Geohydrology / B.Sc. (Engg.) Civil / Agriculture and Allied Sciences with 16 years of Education or Equivalent.
- No third division in the whole career.
- CGPA on a scale other than 4.00 will be converted accordingly.

7. Duration of the program

The CEES is following the HEC guidelines and MS/M. Phil degree is awarded by the university after a minimum of two (2) years period. The general timeline followed by the CEES is two years. Number of courses taught in MS/M. Phil Applied Hydrology degree program will be 8 with each course having 3 credit hours. A total of 12 credit hours of courses are taught in each semester (6 credit hours of core courses and 6 credit hours of

elective courses). After successful completion of course work, students' have to conduct thesis/research work having 6 credit hours.

The college designated competent authority (DDPC) will determine whether the delay is caused by circumstances beyond the student's control and if so, grant an extension for two years in such exceptional circumstances. The date of notification of the award of the MS/M. Phil degree after the MS/M. Phil defence is considered to be the date of the completion of MS/M. Phil studies.

8. Categorization of courses

Semester	Courses	Core Courses	Major Elective	Minor Electives	Any Other	Semester Load
1st	05	06	03	03	--	12
2nd	05	06	03	03	--	12
HEC Guidelines	-	12	6	6	--	24
Difference HEC & PU	--	NIL	NIL	NIL	NIL	NIL

9. Scheme of studies

Sr. #	Code	Course Title	Course Type	Pre-requisite	Credit Hours
Semester I					
1.	HYD 501	Investigation & Development of Water Resources	Core Course	BS/MSc Hydrology & WRM or related subjects	3+0
2.	HYD 502	Flood Estimation and Control	Core Course	--	2+1
3.	HYD 503	Groundwater Resources	Minor Elective	--	3+0
4.	HYD 504	Stochastic Hydrology	Major Elective	--	3+0
5.	HYD 505	Advanced Hydrometry	Minor Elective	--	2+1
				Total Credit hrs Semester-I	**12**
Semester II					
6.	HYD 506	Sediment Transport and Control	Core Courses	BS/MSc Hydrology & WRM or related subjects	2+1
7.	HYD 507	Dams Engineering	Core Course	--	3+0
8.	HYD 508	Computer Models in Hydrology	Major Elective	--	2+1
9.	HYD 509	Natural Hazards	Minor Elective	--	3+0
10.	HYD 510	Hydrology of Cold Regions	Minor Elective	--	2+1
				Total Credit hrs Semester-II	**12**
Semester III& IV					
11.	HYD 601	Dissertation (Based on original research)	Core Course	--	06
				Grand Total (I+II+III+IV):	**30**

10. Award of degree

As a requirement, 02 Year MS/ M. Phil degree will be awarded on the successful completion of courses & syllabi and research thesis with minimum required CGPA 2.5/4.00. After completing course work, the student is officially allowed to start the research and DPCC evaluates the projects and refers to the advanced research board. Each MS/ M. Phil researcher is required to write a thesis that meets the HEC defined criteria. The MS/ M. Phil thesis is supervised by a full-time faculty member who holds a Ph.D. (or equivalent) degree. The MS/ M. Phil thesis is evaluated by the committee member and by at least two external experts. Further, a plagiarism test following the HEC's Plagiarism Policy is conducted on the thesis before its submission to the external experts. An open defense of the thesis is required after a positive evaluation of the thesis by the committee members.

11. NOC if applicable

NA

12. Faculty strength

Degree	Area / Specialization	Total
PhD	1. Prof. Dr. Sajid Rashid Ahmad 2. Prof. Dr. Irfan Ahmad Shaikh 3. Prof. Dr. Nadia Jamil 4. Dr. Abdul Qadir 5. Dr. Yumna Sadef 6. Dr. Muhammad Kamran 7. Dr. Muzaffar Majid Ch. 8. Dr. Azhar Ali 9. Dr. Sana Ashraf 10. Dr. Muhammad Bilal Shakoor 11. Dr. Naeem Akhtar Abbasi 12. Dr. Mehwish Mumtaz 13. Dr. Muhammad Awais 14. Dr. Rizwan Aziz 15. Dr. Muhammad Asif Javed	**15**
MS / M.Phil.	16. Mr. Muhammad Waqar 17. Mr. Muhammad Dastgeer 18. Ms. Zahra Majid 19. Ms. Anum Tariq	**04**

13. Student Teacher ratio

15:19 1:1

HYD-501 INVESTIGATION & DEVELOPMENT OF WATER RESOURCES (THEORY) (03 Credit Hrs.)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes:

- This course will introduce the basics water resources & irrigation network to the students.
- The students will learn about the management of water resources systems.
- They will have the knowledge about the climate change on water resources.
- They will become conversant with the latest techniques of RS/GIS and their application in water resources.

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit- I Water Resources and Irrigation Network

1.1 Introduction to global water resources
1.2 Water Resources of Pakistan
1.3 Irrigation Network & its Components
1.4 Major rivers of Pakistan
1.5 Importance of water resources management

Unit-II Water Resources system Management

2.1 Introduction
2.2 Responsibilities of Irrigation Management Institutions
2.3 Provincial Irrigation Departments (PIDs)
2.4 Organization of PIDs
2.5 Punjab Irrigation Department
2.6 Management Components of PID
2.7 Provincial Irrigation and Drainage Authorities (PIDAs)

Unit-III Climate change and fresh water resources

3.1 Climate, Weather & meteorology
3.2 Climate Changes and Climate variables
3.3 Climate Change predictions
3.4 Uncertainties and their analysis.
3.5 Other Climate Forcing mechanisms
3.6 Impacts of climate change

Unit-IV Remote Sensing and GIS Application in Water Resources

4.1 Remote sensing and Geographical Information System
4.2 Spatial land use and land cover mapping
4.3 Spatio-temporal precipitation
4.4 Soil moisture mapping for floods and droughts
4.5 Spatially distributed crop water use estimations
4.6 Spatial groundwater use
4.7 Satellite imagery retrieval

Unit-V Economics of Water Resources

1.1 Introduction
1.2 Market and Non-Market Valuation of Water
1.3 Water as Public and Private Good
1.4 Water Productivity
1.5 Pricing of Irrigation Water
1.6 History of Irrigation Water Charges in Pakistan
1.7 Water Pricing, Markets and practices

Unit-VI Planning of water resource projects

6.1 Physical and economic Factors
6.2 Environmental impacts
6.3 Selection of a Project Plan
6.4 Investigations
6.5 Planning of Reservoirs

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- attitude and behavior,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Max Guthrie (2018). *Ground and Surface Water Hydrology*. Larsen and Keller Education
2. Balek, .J, (2016). *Groundwater Resources Assessment*. Elsevier Science Publishers B. V.
3. Chin, D. A., Mazumdar, A., & Roy, P. K. (2013). *Water-resources engineering* (Vol. 12). Englewood Cliffs: Prentice Hall.
4. Agnew, C., & Woodhouse, P. (2010). *Water resources and development*. Routledge.
5. Asawa, G. L., (2008). *Irrigation & Water Resources Engineering*. New Age International.

HYD-502 FLOOD ESTIMATION AND CONTROL (THEORY) (02 CREDIT HRS)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes:

- This course will provide the basic concepts floods, classifications and importance
- Estimation of floods gauged and ungauged catchments using different techniques
- Application of statically methods in flood studies
- Flood control practices and forecasting

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I General Overview on Floods

1.1 Definitions and classification of floods
1.2 Introduction to flood estimation and design
1.3 Philosophy and meaning of frequency
1.4 Introduction and importance of flood control practices

Unit-II Flood Estimation for Ungauged and Gauged Catchments

2.1 Peak Flow determination,
2.2 Flood determination for gauged and ungauged catchments
2.3 Flood determination for ungauged catchments with frequency relationship
2.4 Flood estimation from catchment characteristics

Unit-III Flood Statistics

3.1 Flood estimation by statistical method
3.2 Flood frequency analyses
3.3 Probable maximum precipitation and Probable maximum flood studies (PMP & PMF)
3.4 Regional flood frequency analysis
3.5 Flood routing techniques

Unit-IV Flood Control Practices

4.1 Classifications of flood control methods
4.2 Flood control reservoirs and retarding basins
4.3 Design and construction of flood control leeves
4.4 Channel improvements
4.5 Soil conservation measures for flood protection
4.6 Combination of flood control measures

Unit -V Flood Forecasting and Disaster Management System

5.1 Flood forecasting and warning, results of controlling floods
5.2 Disaster management and floods
5.3 Emergency evacuation and rescheduling
5.4 Structural adjustment and land use change
5.5 Insurance and flood control economics

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Bedient, P. B., Huber, W. C., & Vieux, B. E. (2019). *Hydrology and Floodplain Analysis*. Pearson
2. Riedel, J. T. (2019). *Comparison of Generalized Estimates of Probable Maximum Precipitation With Greatest Observed Rainfalls.* Forgotten Books.
3. Borodavko, P. S., Glazirin, G. E., & Herget, J. (2013). *Hazard Assessment and Outburst Flood Estimation of Naturally Dammed Lakes in Central Asia.* Shaker Verlag GmbH, Germany
4. Fatima, A. (2012). E*stimation of Peak Flood Discharges in the Hingol River, Pakistan: An Application of HEC-HMS, LAP LAMBERT.* Academic Publishing.
5. Faulkner, Alice Robson 2011. Flood Estimation Handbook, Centre for Ecology & Hydrology
6. Reed, D. W., Duncan D.W. Reed, Faulkner, D., & Robson, A. (2011). *Flood Estimation Handbook*. Centre for Ecology & Hydrology.
7. World Meteorological Organization. (2009). *Manual on estimation of probable maximum precipitation (PMP)*. World meteorological organization.
8. Mutreja, K.N. (1987). *Applied Hydrology*. McGraw-Hill Book Comp.

HYD-502 FLOOD ESTIMATION AND CONTROL(PRACTICAL) (01 Credit Hrs)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes:

- This course will provide the basic concepts about the flood data and its management
- Examples for estimation of floods gauged and ungauged catchments using different techniques
- Application of statically methods in flood studies
- use of selected software for flood estimations

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I

1.1 Hydrograph analysis

Unit-II

2.1 Interpretation of Creager Curve

Unit-III

3.1 Development and applications of frequency curves

Unit-IV

4.1 Practical Examples of Flood Estimation in ungauged catchments
4.2 Practical Examples of Flood Estimation in gauged catchments

Unit-V

5.1 Use of computer software such as HEC-HMS for Flood Analysis

Unit-VI

6.1 Calculation procedure for of PMF and PMP

Unit-VII

7.1 Case studies and practical application

Unit-VIII

8.1 Interpretation of historic flood events in Pakistan

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments, and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Bedient, P. B., Huber, W. C., & Vieux, B. E. (2019). *Hydrology and Floodplain Analysis*. Pearson
2. Riedel, J. T. (2019). *Comparison of Generalized Estimates of Probable Maximum Precipitation With Greatest Observed Rainfalls.* Forgotten Books.
3. Fatima, A. (2012). E*stimation of Peak Flood Discharges in the Hingol River, Pakistan: An Application of HEC-HMS, LAP LAMBERT.* Academic Publishing.
4. Borodavko, P. S., Glazirin, G. E., & Herget, J. (2013). *Hazard Assessment and Outburst Flood Estimation of Naturally Dammed Lakes in Central Asia.* Shaker Verlag GmbH, Germany.
5. Faulkner, Alice Robson 2011. Flood Estimation Handbook, Centre for Ecology & Hydrology
6. Reed, D. W., Duncan D.W. Reed, Faulkner, D., & Robson, A. (2011). *Flood Estimation Handbook*. Centre for Ecology & Hydrology.
7. World Meteorological Organization. (2009). *Manual on estimation of probable maximum precipitation (PMP)*. World meteorological organization.
8. Mutreja, K.N. (1987). *Applied Hydrology*. McGraw-Hill Book Comp.

HYD-503 GROUNDWATER RESOURCES (THEORY) (03 Credit hrs)

Pre-requisite: **BS/**M.Sc Hydrology &WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes:

- This course will introduce the basic concepts of ground water resources assessment to the students.
- The students will learn about the analysis & synthesis of groundwater balance components.
- They will have the knowledge about the groundwater resources formation.
- They will become conversant with the system approach of groundwater resources assessment
-

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit- I Hydrological Approach in Groundwater Resources Assessment

1.1 Hydrological and hydrogeological regions
1.2 Watershed. catchment and drainage basin
1.3 Components of the water balance equation
1.4 Saturated and unsaturated soil zones
1.5 Evapotranspiration in the water balance approach
1.6 Evaporation from free water surface and from snow
1.7 Role of meteorology and climatology

Unit-II Water Balance

2.1 Groundwater-stream network interaction
2.2 Water balance in semi-arid, arid and humid regions
2.3 Complex water balance equations
2.4 Stabilization of the water balance components

Unit-III Groundwater resources formation and the safe yield Concept

3.1 Infiltration. percolation and seepage
3.2 Natural recharge of groundwater
3.3 Groundwater storage
3.4 Safe yield. groundwater exploitation and groundwater mining

Unit- IV The system approach to groundwater resources assessment

4.1 Identification of the problem and constraints
4.2 Temporary monitoring network
4.3 Missing records
4.4 Identification of working methods
4.5 Analysis of the groundwater regime

Unit-V Groundwater assessment and management

5.1 Probability concept in safe yield analysis
5.2 Effects of land use upon the groundwater regime
5.3 Protective measures in regions with steadily declining groundwater level
5.4 Artificial recharging methods
5.5 Conjunctive use of water

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Max Guthrie (2018). *Ground and Surface Water Hydrology*. Larsen and Keller Education
2. Balek, J., (2016). *Groundwater Resources Assessment*. Elsevier Science Publishers B. V.
3. Fares. A, (2016). *Emerging Issues in Groundwater Resources*, Springer International Publishing
4. Mandel, S., (2012). *Groundwater Resources: Investigation and Development*. Elsevier
5. Charles, F., (2012). *Groundwater Science*. Academic Press.

HYD 504 STOCHASTIC HYDROLOGY (THEORY) (03 Credit hrs.)

Pre-Requisite: BS/M.Sc. Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes:

- This course will provide an introduction to hydrological time series analysis
- The students will learn about the concepts of Probability functions and its application
- They will have the knowledge about the linear stochastic models and special properties of models
- The students will get used to the concepts of statistical treatment of floods and its applications to water resources systems
- They will become conversant with stochastic programming and applied decision theory

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I Date requirements and time series analysis

1.1 Introduction to hydrological time series
1.2 Filtering methods
1.3 Trend analysis and randomness
1.4 Autocorrelation
1.5 Spectral methods

Unit-II Probability functions and their uses

2.1 Probability density function
2.2 Estimation by method of Moments
2.3 Maximum likelihood methods for estimation
2.4 Goodness of fit tests
2.5 The families of probability function
2.6 Random numbers, generation and transformation

Unit-III Linear stochastic Models

3.1 Introduction to data generation
3.2 Linear autoregressive models
3.3 Partial autocorrelation
3.4 Moving average models
3.5 Box-Jenkins models
3.6 Application of non-normal series
3.7 Seasonal models
3.8 Multisite data generation models
3.9 Short term forecasting

Unit-IV Special Properties and Models

4.1 Runs and crossing properties
4.2 Ripple diagram and reservoir storage
4.3 Fraction Gaussian Noise
4.4 Broken line models

Unit-V Statistical Treatment of Floods

5.1 Hydrological maximum series and return period
5.2 Extreme value distributions
5.3 Gumble distribution
5.4 General extreme value distribution
5.5 Lognormal distribution
5.6 Pearson type III function applied to extreme values
5.7 Flood frequency methods
5.8 Regional flood frequency analysis
5.9 Probable maximum precipitation and floods

Unit-VI Probability theory and Reservoir Storage

6.1 Introduction of probability to water storage
6.2 Markove chain model's application to water systems
6.3 Morans's theory of reservoir
6.4 Gould method for failure analysis
6.5 Serial correlation and seasonal change analysis

Unit-VII Stochastic Programming Methods

7.1 Introduction to system engineering
7.2 Linear programming
7.3 Dynamic programming

Unit-VIII Applied Decision theory

8.1 Introduction to decision theory to water resources
8.2 Bayesian decision making
8.3 Applications of Bayesian theory to hydrological problems

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- classroom participation,
- attendance, assignments and presentation,
- homework
- attitude and behavior,
- hands-on-activities,
- short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Gómez-Hernández, J. J., Li, L., Xu, T., & Alcolea, A. (2021). *Stochastic Modeling in Hydrogeology*. Frontiers Media SA
2. Barbu, V. S., & Vergne, N. (2020). *Statistical Topics and Stochastic Models for Dependent Data with Applications*. Wiley
3. Gupta, R. S., (2016). *Hydrology and Hydraulic Systems*: Fourth Edition. Waveland Press.
4. Naghettini, M., (2016). *Fundamentals of Statistical Hydrology*. Springer International Publishing
5. Kulik, Rafal, Soulier, Philippe 2020 Heavy Tailed Time Series Springer-Verlag New York eBook ISBN; 978-1-0716-0737-4
6. Levendis, John D. Time Series Econometric 2018 Springer International Publishing eBook ISBN;978-3-319-98282-3

HYD 505 ADVANCED HYDROMETRY (THEORY) (02 Credit hrs)

PRE-REQUISITE: BS/M.Sc Hydrology & WRM / Civil/Agriculture Engg. or equivalent

Course Learning Outcomes

The student will learn how to:

- Develop a clear understanding of river and stream field measurement techniques.
- Use water quantity data collected in the field in advanced modeling tools to solve problems.
- Analyze experimental data with a variety of universal data analysis techniques.
- Become familiar with software packages commonly used in industry and research.

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I Introduction

1.1 An introduction to the hydrometry
1.2 Requirement and objectives of hydrometry

Unit-II Flow Measurements

2.1 Measurement of stage
2.2 State-discharge relationships
2.3 Models estimating evapotranspiration
2.4 Sediments measurements
2.5 Ground water measurements

Unit-III Flow velocity measurement and discharge computation

3.1 Flow Velocity
3.2 Flow distribution
3.3 Discharge computation
3.4 Slope-area Method

Unit-IV Hydro meteorological fluxes Gauges

4.1 Preliminaries and reminders
4.2 Current meter velocity gauging
4.3 Electromagnetic current meter
4.4 Acoustic doppler curent profiler (adcp)
4.5 Float gauging
4.6 Dilution (chemical) gauging

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Jain, S. K., & Singh, V. P., (2019). *Engineering Hydrology: An Introduction to Processes, Analysis, and Modeling*. McGraw-Hill Education.
2. Eslamian, S., (2018). *Handbook of Engineering Hydrology* (Three-Volume Set). CRC Press.
3. Chanson, H., Melville, B., Wang, H., Leng, X., & Whittaker, C. (2018). *Experimental Hydraulics: Methods, Instrumentation, Data Processing and Management*. CRC Press,.
4. Shaw, E. M., Beven, K. J., Chappell, N. A., & Lamb, R., (2017). *Hydrology in Practice*. CRC Press.
5. Jones, J. A. A., (2014). *Global hydrology: processes, resources and environmental management*. Routledge.
6. Boiten, W., (2008). *Hydrometry: a comprehensive introduction to the measurement of flow in open channels.*
7. Herschy, R. W., (2008). *Streamflow measurement*. CRC press.
8. Gupta, S. V., (2002). *Practical density measurement and hydrometry*. CRC Press.

HYD 505 ADVANCED HYDROMETRY (PRACTICAL) (1 Credit hrs)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes:

The student will learns how to:

- Developed a clear understanding of river and stream field measurement techniques.
- Used water quality and quantity data collected in the field in advanced modeling tools to solve problems.
- Analyzed experimental data with a variety of universal data analysis techniques.
- Become familiar with software packages commonly used in industry and research.

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I

1.1 Hydrologic measurements using current meters

Unit-II

2.1 Data Processing by using software (HEC-RAS)

Unit-III

3.1 Rating curve
3.2 Acquisition of the physical data
3.3 Construction of the rating curve
3.4 Management of the rating curves

Unit-IV

4.1 GIS and LiDAR
4.2 DEM acquisition and Processing
4.3 Delineating drainage networks

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
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2. Eslamian, S., (2018). *Handbook of Engineering Hydrology* . CRC Press.
3. Shaw, E. M., Beven, K. J., Chappell, N. A., & Lamb, R., (2017). *Hydrology in Practice*. CRC Press.
4. Jones, J. A. A., (2014). *Global hydrology: processes, resources and environmental management.* Routledge.
5. Boiten, W., (2008). *Hydrometry: a comprehensive introduction to the measurement of flow in open channels.*
6. Herschy, R. W., (2008). *Streamflow measurement*. CRC press.

SECOND SEMESTER

Sr. #	Code	Course Title	Course Type	Pre-requisite	Credit Hours
1.	HYD 506	Sediment Transport and Control	Core Courses	BS/MSc Hydrology & WRM or related subjects	2+1
2.	HYD 507	Dams Engineering	Core Course	--	3+0
3.	HYD 508	Computer Models in Hydrology	Major Elective	--	2+1
4.	HYD 509	Natural Hazards	Minor Elective	--	3+0
5.	HYD 510	Hydrology of Cold Regions	Minor Elective	--	2+1
Total Credit hrs Semester-II					**12**

HYD-506: SEDIMENT TRANSPORT AND CONTROL (THEORY) (02 Credit hrs)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes

- This course will provide the basic concepts about water and sediment properties
- The students will learn about the initiation of sediment motion, transport mechanism and bed forms
- The students will learn the about scour and siltation processes
- The students will be able the learn about the design considerations of stable channel in context to sediments.

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I Properties of Water and Transport Material

1.1 Properties of water, density, specific gravity, kinematic viscosity, dynamic viscosity, surface tension,
1.2 Flow conditions (uniform flow, laminar flow, turbulent flow, roughness, diffusion
1.3 Properties of sediment (size, shape, density, fall velocity, porosity)

Unit-II Initiation of Motion

2.1 Particle equilibrium theory
2.2 Factors affecting initiations of Motions

Unit-III Transport Mechanisms, Bed Forms and Alluvial Roughness

3.1 Introduction, bed load, suspended load
3.2 Origin of transported material (bed material transport, wash material)
3.3 Bed forms (lower flow regime bed forms, upper flow regime bed forms)
3.4 Classification criterion
3.5 Alluvial roughness

Unit-IV Bed Material Transport

4.1 Transport Equation/Model for bed load
4.2 Transport Equation /Model for suspended load
4.3 Transport Equation /Model for total load

Unit-V Stable Channels, Scour and Siltation

5.1 Sediment carrying capacity of channel.
5.2 Erosion and sedimentation of cohesive material.
5.3 Degradation, aggradations and local scour in alluvial channel.
5.4 Stable alluvial channel design.

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments, and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Tigrek, S., & Aras, T. (2019). *Reservoir sediment management*. CRC Press.
2. Uncles, R. J., & Mitchell, S. B. (2017) *Estuarine and Coastal Hydrography and Sediment Transport 1st Edition*, Cambridge University Press.
3. Khan, A. A., & Wu, W. (2013). *Sediment Transport: Monitoring, Modeling and Management*. Nova Science Publishers Incorporated
4. Pitlick, J., Cui, Y., Service, F., & Agriculture, U. S. (2012). *Sediment Transport Primer: Estimating Bed-material Transport in Gravel-bed Rivers*. CreateSpace Independent Publishing Platform.
5. Young, C. T. (2003) *Sediment Transport: Theory and Practice.* Krieger Pub Co.
6. Morris, G. L., & Fan, J. (1997). R*eservoir Sedimentation Handbook: Design and Management of Dams, Reservoirs, and Watersheds for Sustainable Use*. McGraw-Hill.
7. Simons, D. B., & Şentürk, F. (1992). *Sediment transport technology: water and sediment dynamics*. Water Resources Publication.

HYD-506 SEDIMENT TRANSPORT AND CONTROL (PRACTICAL) (01 Credit hrs)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes

- Students will be able to learn about the sediment sampling techniques for bed load and suspended load.
- Students will be able to perform analyses of transport material
- Students will be able to interpret about the sediment data and its applications
- Students will learn about the applications of selected software for sediment studies.

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I Sediment Sampling Techniques

1.1 Overview to measurement techniques
1.2 Bedload sampler
1.3 Suspended load sampler
1.4 Tracer techniques

Unit-II Analyses of Transport Material

2.1 Sieve Analysis
2.2 Grain Size Curve development and Applications
2.3 Representation of Sediment data
2.4 Interpretation of Sediment data

Unit-III Computer Software for Sediment Transport

3.1 Overview of HEC-RAS software for sediment transport studies
3.2 Practical Applications of HEC-RAS

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Tigrek, S., & Aras, T. (2019). *Reservoir sediment management*. CRC Press.
2. Uncles, R. J., & Mitchell, S. B. (2017) *Estuarine and Coastal Hydrography and Sediment Transport 1st Edition*, Cambridge University Press
3. Khan, A. A., & Wu, W. (2013). *Sediment Transport: Monitoring, Modeling and Management*. Nova Science Publishers Incorporated
4. Pitlick, J., Cui, Y., Service, F., & Agriculture, U. S. (2012). *Sediment Transport Primer: Estimating Bed-material Transport in Gravel-bed Rivers*. CreateSpace Independent Publishing Platform.
5. Young, C. T. (2003) *Sediment Transport: Theory and Practice.* Krieger Pub Co.
6. Morris, G. L., & Fan, J. (1997). R*eservoir Sedimentation Handbook: Design and Management of Dams, Reservoirs, and Watersheds for Sustainable Use*. McGraw-Hill.
7. Simons, D. B., & Şentürk, F. (1992). *Sediment transport technology: water and sediment dynamics*. Water Resources Publication.

HYD 507 DAMS ENGINEERING (THEORY) (03 Credit Hours)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes:

- This course will provide an introduction to dams and reservoirs
- The students will learn about the concepts of dam geology
- They will have the knowledge about types of dams
- The students will get used to the concepts dam construction
- They will become conversant with dam safety

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I Introduction of dams and reservoirs

1.1 Description of a dam
1.2 Classification, Types of dams
1.3 Advantages & Disadvantages of dams
1.4 Site selection criteria

Unit-II Planning & Design of a Dam

2.1 Planning & Design Stages
2.2 Dam Site selection
2.3 Components of a dam
2.4 Outlet Works
2.5 Hydropower Development

Unit-III Geological & Geotechnical Studies for Dam Design

3.1 Objectives of the study
3.2 Foundation material Investigations
3.3 Rock features for classification
3.4 Rock forming minerals
3.5 Geological requirements of a dam
3.6 Foundation preparations & failures

Unit-IV Embankment Dams

4.1 Earth fill Dams & Rock fill Dams
4.2 Design criteria, Types, Foundation design,
4.3 Seepage-analysis, Control and mitigation,
4.4 Embankment design (core, crest, free board, slopes, materials, filter and its types).

Unit-V Gravity Dams

4.1 Loads, Concrete Dams
4.2 Dam stability, stress analysis, profile selection
4.3 Arch dam: Layout/arch geometry and profile, arch stress analysis, thin or thick arch
4.4 Buttress Dams
4.4 Force analysis, abutment strength.

Unit-VI Spillways

5.1 Functions and Classification of Spillways
5.2 Types of Spillways
5.3 Design criteria
5.4 Gates and valves
5.5 Emergency & Service Spillways

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Petar, M,. (2018). *Engineering Karstology of Dams and Reservoir*s 1st Edition. CRC Press.
2. Robin, F., et.al., (2018). *Geotechnical Engineering of Dams* 2nd Edition. CRC Press.
3. Satter, A., Ghulam M. I., (2015). *Reservoir Engineering: The Fundamentals, Simulation, and Management of Conventional and Unconventional Recoveries* 1st Edition, Gulf Professional Publishing
4. British Dam Society (2014). *Maintaining the Safety of our Dams and Reservoirs*. ICE Publishing,
5. Barry. L., (2013). *Small Dams: Planning, Construction and Maintenance* 1st Edition, CRC Press.

HYD-508 COMPUTER MODELS IN HYDROLOGY (THEORY) (02 Credit hrs)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Syllabus Outline

Course Learning Outcomes

- Students will be able to learn about the basic concepts and applications computer models in hydrology.
- Students will be trained about model classifications
- Students will be able to handle the input data and involved preprocesses
- Students will learn about the applications of selected computer models for surface water simulation.
- Students will learn about the applications of selected computer models for simulation of ground water.

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I Introduction to Hydrological Processes

1.1 Catchment processes and hydrologic losses
1.2 Catchment characteristic and morphology
1.3 Runoff generation, theories and factors affecting runoff
1.4 Introduction to catchment modeling, applications and importance

Unit-II Classifications of Hydrological Models

2.1 Conceptual watershed modeling
2.2 Computer simulation approaches in catchment hydrology,
2.3 Types of catchment models,
2.4 Black box models
2.5 Conceptual models
2.6 Semi-distributed models
2.7 Distributed models

Unit-III Computer Application for Inputs & Data Preprocessing

3.1 Common forcing data (temporal and spatial data for computer models)
3.2 Rain/snow partitioning
3.3 Loss estimation
3.4 Spatial Interpolation and estimation of missing data
3.5 GIS based watershed analysis
3.6 Handing and archiving to land use and soil data in computer

Unit-IV Computer Models for Surface Water Analyses

4.1 Hydrological modeling using (HEC-HMS
4.2 Hydrological modeling using HBV
4.3 River Analyses using HEC-RAS
4.4 Simulation of Storm Water using EPA's SWMM

Unit-V Computer based Modeling for Ground Water Analyses

5.1 Review of MODFLOW package for ground water modelling
5.2 Model development in MODFLOW
5.3 Model calibration and validation
5.4 Particle tracking and solute transport modeling

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

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- Classroom participation,
- Attendance, assignments and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- Short tests, quizzes etc.

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RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Khan, A. A., (2019). *Modeling shallow water flows using the discontinuous Galerkin method*. CRC Press.
2. Mazzoleni, M. (2017). *Improving flood prediction assimilating uncertain crowdsourced data into hydrologic and hydraulic models*. CRC Press.
3. Guo, J. C., (2017). *Urban flood mitigation and stormwater management*. CRC Press.
4. Gupta, R. S., (2016). *Hydrology and hydraulic systems*. Waveland Press.
5. Sen, Z., (2009). *Fuzzy logic and hydrological modeling*. CRC Press.
6. Singh, V. P., (1995). *Computer models of watershed hydrology*. Water Resources Publications.

HYD-508 COMPUTER MODELS IN HYDROLOGY (PRACTICAL) (01 Credit hrs)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes

- Students will be able to learn management and processing of hydrological data
- Students will be trained about setting up computer models, creating input data files, and model calibration and validation of computer-based models
- Students will learn about documentation and reporting methods of model studies

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I Practical Performances for Inputs and Data Processing

1.1 Practical aspects of input data collection, evaluation and archiving
1.2 Practical estimation of Evapotranspiration using spreadsheet models and software packages
1.3 Practical for Watershed Analysis (Watershed delineation, Calculation of contribution areas,
1.4 Drainage channels, slope and length of drainage channels using Arc-Hydro TOOL Erdas Imagine and QGIS)

Unit-II Practical Performance of Hydrological Models, Model Set-up, Input Files, Calibration, Validation and Forecasting

2.1 HEC- HMS model
2.2 HBV model
2.3 HEC-RAS
2.4 EPA's SWMM

Unit-III Documentation and Reporting of Model Studies

3.1 Performance Evaluation of Models (Graphical and Statistical Methods)
3.2 Graphical and Tabular presentations of Model simulation results

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

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- Homework
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- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

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3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

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3. Guo, J. C. (2017)., *Urban flood mitigation and stormwater management*. CRC Press.
4. Gupta, R. S., (2016). *Hydrology and hydraulic systems*. Waveland Press.
5. Sen, Z., (2009). *Fuzzy logic and hydrological modeling*. CRC Press.
6. Singh, V. P., (1995). *Computer models of watershed hydrology*. Water Resources Publications.

HYD 509 NATURAL HAZARDS (THEORY) (0**3 Credit hours)**

Pre-requisite: BS/M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes:

- This course will provide an advance knowledge about Natural Hazards
- The students will learn about the concepts of Geotechnical description of Natural Hazards
- They will have the knowledge about Floods and landslides.
- The students will be familiarized with the concepts earthquake Tsunami and avalanches.
- They will become conversant with hazards related to climate change

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I Introduction

1.1 Fundamental concepts of Natural Hazards
1.2 Geotechnical description of the area
1.3 Geological hazards and their remedial measures
1.4 Natural Catastrophes
1.5 Emergency response and mitigation strategies

Unit-II Floods as a Hazard

2.1 Flooding process
2.2 River system
2.3 Stream flow and sediment transport
2.4 Channel pattern,
2.5 flow and debris flow
2.6 Effects of flood on agro-economy.

Unit-III Landslides and their Remedial Measures

3.1 Types of landslides,
3.2 Their causes and remedial measures of landslides
3.3 Mitigation of damages from landslides.
3.4 Sink holes,
3.5 Land subsidence
3.6 Swelling soils.

Unit-IV Plate Tectonic and Hazards

4.1 Plate tectonics
4.2 Tectonic movement
4.3 Plate boundaries
4.4 Sea floor spreading
4.5 Volcanic activities

Unit-V Earthquake

5.1 Earthquake hazards and their Causes
5.2 Earthquake waves, size
5.3 Characteristics of earthquake
5.4 Earthquake prediction
5.5 Mitigation

Unit-VI Tsunami

6.1 Tsunami
6.2 Generation of Tsunami
6.3 Movement of Tsunami
6.4 Tsunami mitigation
6.5 Snow avalanches

Unit-VII Climate Change and Global Warming as Hazards

7.1 Climate change and weather related hazards
7.2 Basic elements of climate and weather
7.3 Greenhouse effect
7.4 Global warming
7.5 Drought
7.6 Dust storm
7.7 Desertification
7.8 Heat waves.

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Ramesh, S., (2018). *Natural Hazards: Earthquakes, Volcanoes, and Landslides* .1st Edition, CRC Press.
2. Burrell E. M, Graham A. T., (2017) .*Natural Hazards*: *Explanation and Integration*. Second Edition, The Guilford Press.
3. Donald, H., David H., (2016). *Natural Hazards and Disasters* 5th Edition, Cengage learning,
4. Edward, A., (2014). *Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes*. 4th Edition, Routledge
5. Keller., (2012). *Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes*. 3rd Edition, Prentice Hall.

HYD 510 HYDROLOGY OF COLD REGIONS (THEORY) (02 Credit hours)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes:

- This course will provide an introduction to Snow measurements
- The students will learn about the concepts of glaciers
- They will have the knowledge about runoff estimation form snow
- The students will get used to the concepts earthquake snow modeling

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I Snow Classification

1.1 Snow and its classification
1.2 Distribution of snow
1.3 Ripening of snow

Unit-II Snow Melting

2.1 Snowmelt process
2.2 Measurement of snow at time of fall
2.3 Snow surveying

Unit-III Factors Affecting Runoff

3.1 Factors affecting runoff from snowmelt
3.2 Techniques of analysis of snowmelt
3.3 Forecasting snow melt runoff

Unit-IV Properties of Snow

4.1 Snow compaction
4.2 Properties and structure of ice
4.3 Types avalanches

Unit-V Glaciers

5.1 Avalanches
5.2 Glaciers
5.3 Movement of glaciers
5.4 Impacts of glaciers
5.5 Glaciers in Pakistan

Unit-VI Snowmelt Modeling

6.1 Snow modeling for runoff
6.2 Types of snowmelt models
6.3 Properties of Snowmelt models

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

RECOMMENDED TEXT BOOKS / SUGGESTED READINGS

1. Carry, J., (2016). *Handbook of Snow, Ice and Glaciers*. Syrawood Publishing House.
2. Singh, V. P., (2011*). Encyclopedia of Snow, Ice and Glaciers*. Springer.
3. DeWalle, D. R., Rango A., (2011), *Principles of Snow Hydrology* Reissue Edition, Cambridge University Press
4. Cuffey, K. M., Paterson W. S. B., (2010). *The Physics of Glaciers.* 4th Edition, Academic Press.
5. Singh, P., (2001), *Snow and Glacier Hydrology (Water Science and Technology Library).* Springer.

HYD 510 HYDROLOGY OF COLD REGIONS (PRACTICAL) (01 Credit hours)

Pre-requisite: **BS/**M.Sc Hydrology & WRM/ Civil/Agriculture Engg. or equivalent

Course Learning Outcomes:

- This course will provide an introduction to Snow measurements
- The students will learn about the concepts of glaciers
- They will have the knowledge about runoff estimation form snow
- The students will get used to the concepts earthquake snow modeling

Contents

This course aims at providing students with the necessary knowledge and understanding to the following:

Unit-I Measurements of Snow

1.1 Measurement of snow
1.2 Snow surveying

Unit-II Snow Melting Estimation

2.1 Runoff from snowmelt estimation methods
2.2 Snow compaction methods

Unit-III Practical Aspects of Glaciers

3.1 Properties and structure of ice
3.2 Detail Investigation of avalanches
3.3 Investigation of glaciers snowmelt runoff

Unite-IV Snowmelt Modeling

4.1 Snow modeling for runoff
4.2 Practical performance of snow melt runoff

TEACHING – LEARNING STRATEGIES

- Lecture based examination
- Presentation/seminars
- Class discussion
- Quizzes

ASSIGNMENTS – TYPE AND NUMBER WITH CALENDAR

It is continuous assessment. The weightage of Assignments will be 25% before and after midterm assessment. It includes:

- Classroom participation,
- Attendance, assignments and presentation,
- Homework
- Attitude and behavior,
- Hands-on-activities,
- Short tests, quizzes etc.

ASSESSMENT AND EXAMINATIONS:

Sr. No.	Elements	Weightage	Details
1.	Mid Term Assessment	35%	It takes place at the mid-point of the semester
2.	Formative Assessment	25%	It is continuous assessment. It includes: classroom participation, attendance, assignments and presentation, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.

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Parameters	
1. Department Mission and Introduction	✓
2. Program Introduction	✓
3. Program Alignment with University Mission	✓
4. Program Objectives	✓
5. Market Need/ Rationale	✓
6. Admission Eligibility Criteria	✓
7. Duration of the Program	✓
8. Assessment Criteria	✓
9. Courses Categorization as per HEC Recommendation	✓
10. Curriculum Difference	✓
11. Study Scheme / Semester-wise Workload	✓
12. Award of Degree	✓
13. Faculty Strength	✓
14. NOC from Professional Councils (if applicable)	NA

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Program Coordinator **Principle**