தமிழ்நாடு மத்தியப் பல்கலைக்கழகம்

CENTRAL UNIVERSITY OF TAMIL NADU

तमिलनाडु केन्द्रीय विश्वविद्यालय

ESTABLISHED BY AN ACT OF PARLIAMENT IN 2009

Ph.D. Programme

Curriculum Structure

(2022 Onwards)

Department of Geology

School of Earth Sciences,

Central University of Tamil Nadu,

Thiruvarur-610005

Email: hodgeology@cutn.ac.in

A. Vision

To produce and sustain the conditions that enable the students to experience transformative learning in becoming independent and ideal learners through education of global standards. This would be achieved by maintaining high academic standards, sustaining the quality of science teaching, learning offered, providing an intellectual, personal, and socially transformative experience to students.

B. Mission

M1 To provide student-centric learning environment through scientific and innovative pedagogy

M2 To create excellent infrastructure facilities and state-of-the-art laboratories

M3 To encourage research and industry-institute partnerships through collaborative activities for innovation and development

M4 To promote conferences/seminars/workshops/society development programs for creation of avenues for research exchange and knowledge enhancement in thrust areas

M5 To enhance leadership qualities, ethical and moral values, research culture and innovative skills among the students by offering high quality education and other services in a competitive manner

C. Program Educational Objectives (PEO) – Ph.D.

After successful completion of the Doctoral Research Course Work, the scholar will be able to

PEO1 Develop a desire to keep learning throughout life

PEO2 Mould scholars to work in a professional setting

PEO3 Constantly update themselves in areas to their career

PEO4 Develop high level of thinking and problem-solving skills

PEO5 Address the societal needs and work for betterment of society

PEO6 Visualise complex problems in a global scale

PEO7 Train the scholars to conduct independent research as well as working in a team

D. Attributes for Ph.D. in Geology

1. **Disciplinary Knowledge:** Content and pedagogical knowledge synchronised with the geoscience research frameworks
2. **Communication Skills:** Conveying the geo-scientific understanding, ideas, and concepts with Scientific and Technological communities.
3. **Critical Thinking:** Capacity to apply their skills through experimental, analytical, numerical, and model-based research.
4. **Problem Solving:** To identify the research gaps and appropriate remedies for various issues in Earth Sciences.
5. **Co-operation:** Effective collaboration among different organisations and industries working in the domain of geo/planetary sciences.
6. **ICT Skills:** Selecting and integrating appropriate geoscientific technological skills for personal, professional development and knowledge dissemination.
7. **Ethics:** To develop the basics of ethics, research integrity, moral principles, and professional ethics.

E. PEO to Mission Statement Mapping

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6	PEO7
M1	✓	✓	✓	✓	✓	✓	✓
M2	✓	✓	✓	✓	✓	✓	✓
M3	✓	✓	✓	✓	✓	✓	✓
M4	✓	✓	✓	✓	✓	✓	✓
M5	✓	✓	✓	✓	✓	✓	✓

F. Program Outcomes (PO)

On the successful completion of the program, the student will be able to

PO1 Will be able to identify the knowledge gaps for further understanding.

PO2 Structuring the methodology, execution and designing of research work.

PO3 Analyse critical data/ results and their interpretation for simpler understanding.

PO4 Impact the skills to communicate the research with the scientific community through peer-reviewed publications at the national and international levels.

PO5 Inculcate the practice of performing research professionally, ethically and responsibly.

PO6 Develop substantial skills in solving geological problems for societal benefits.

G. PO to PEO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	✓	✓	✓	✓	✓	✓
PEO2	✓	✓	✓	✓	✓	✓
PEO3	✓	✓	✓	✓	✓	✓
PEO4	✓	✓	✓	✓	✓	✓
PEO5	✓	✓	✓	✓	✓	✓
PEO6	✓	✓	✓	✓	✓	✓
PEO7	✓	✓	✓	✓	✓	✓

Programme Structure

Semester	Courses		Credits		Assessment	
	Code	Title	L	Total	CIA	ESE
First Semester						
I	GLYDRC01	Research Methodology*	4	4	40	60
I	GLYDRC02	Research and Publication Ethics (RPE)*	2	2	40	60
I	GLYDRC03	Analytical Techniques in Geosciences and Seminar*	4	4	40	60
I	-	Specific Research Course (SRC) **	4	4	40	60
			Total	**14**	**400**	

Option for Research Specific Course

I	GLYSRC01	Geospatial Technology and Modelling in Groundwater Resources	4	4	40	60
I	GLYSRC02	Advances in Structural Geology	4	4	40	60
I	GLYSRC03	Applied Geochemistry	4	4	40	60
I	GLYSRC04	Geomechanics	4	4	40	60
I	GLYSRC05	Hazards and Risk Impact Assessment	4	4	40	60
I	GLYSRC06	MOOC/ SWAYAM /NPTEL Course	4	4	40	60
CIA: Continuous Internal Assessment			ESE: End Semester Examination			
DRC: Department Research Course			SRC: Specific Research Course			

Note: Research Scholar have to complete their course work within a year from date of admission with minimum credits of 14.

**Compulsory Courses*

***SRC shall be floated in every academic year and research scholar can choose any one or more courses based on the Research Supervisor and Research Advisory Committee (RAC) suggestions and recommendations.*

d. Common Evaluation Scheme for all the courses

- **Theory course with a credit of 4**

	CO1	CO2	CO3	CO4	Total
Internal/ Assignments	10	10	10	10	40
External	15	15	15	15	60
Total	**25**	**25**	**25**	**25**	**100**

- **Theory course with a credit of 2**

	CO1	CO2	Total
Internal/ Assignments	20	20	40
External	30	30	60
Total	**50**	**50**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

- **Theory course with a credit of 4**

	CO1	CO2	CO3	CO4
Assignments	2	2	2	2
Seminar	2	2	2	2
Test	5	5	5	5
Attendance	1	1	1	1
Total	10	10	10	10

- **Theory course with a credit of 2**

	CO1	CO2
Assignments	4	4
Seminar	4	4
Test	10	10
Attendance	2	2
Total	20	20

f. Common Mapping Course Outcome with External Assessment (60 Marks)

- **Theory course with a credit of 4**

Category	CO1	CO2	CO3	CO4
Part – A (Objective - 10 x 1 = 10 marks)	3	2	3	2
Part – B (Short Answer - 5 x 4 = 20 marks)	5	5	5	5
Part – C (Essay- 3 x 10 = 30 marks)	7	8	7	8
Total	**15**	**15**	**15**	**15**

- **Theory course with a credit of 2**

Category	CO1	CO2
Part – A (Objective - 10 x 1 = 10 marks)	6	4
Part – B (Short Answer - 5 x 4 = 20 marks)	10	10
Part – C (Essay- 3 x 10 = 30 marks)	14	16
Total	**30**	**30**

g. Common Rubric for Assignments

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Content 50%**	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	
2	**Organiza-tion 50%**	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organisational tools are weak or missing	No organisation	Not attended	

h. Common Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	**Knowledge and Understanding** **50%**	Exceptional knowledge of facts, terms and concepts	Detailed knowledge of facts, terms and concepts	Considerable knowledge of facts, terms and concepts	Minimal knowledge of facts, terms and concepts	Not Attended	
2	**Presentation** **50%**	Well Communicated with logical sequences, examples and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	

i. Common Model Question Paper

Part A **[10 x 1= 10]**

(Objective type: multiple choice, fill in the blanks, one word answer)

*Answer **ALL** the questions. Each Question carries one mark.*

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Part B **[4 x 5= 20]**

(Short answer type: answer should not exceed 200 words)

*Answer **ALL** the questions. Each Question carries five marks.*

11. (a) or (b)
12. (a) or (b)
13. (a) or (b)
14. (a) or (b)

Part C **[3 x 10 = 30]**

(Essay answer type: answer should not exceed 400 words)

*Answer **ALL** the questions. Each Question carries ten marks.*

15. (a) or (b)
16. (a) or (b)
17. (a) or (b)

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLY DRC01	Research Methodology	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Provide students with the fundamental knowledge of research methods	Understand
CO2	Design used in and analyse and interpret methods of quantitative and qualitative data.	Understand
CO3	Understand how using valid scientific methods of measurement and scaling can improve and create knowledge.	Analyse
CO4	Develop, complete, write, and present a valid and ethical research report.	Evaluate

b. Syllabus

Units	Content	Hrs.
I	Introduction to Research: Basic Research, Pure Research, Applied Research Modern Scientific approach to Research; Interdisciplinary approach and its implications; Methods of Research- Qualitative and quantitative methods of research like Historical, case study, ethnography, exposit facto, documentary and content analysis, survey (Normative, descriptive, evaluative etc.), field and experimental studies;	15
II	Development of research proposal, its elements, identification of research problem-criteria of sources and definition, review of literature and collection of references, development of objectives, development of hypotheses and applications. Skills required for conducting research; sources of research data-primary and secondary sources;	15
III	Concept of sampling, Sampling techniques- concept, types (random, purposive, stratified random, probability and non-probability); Survey and Mapping; Tools and techniques of data collection for qualitative and quantitative research-observation, interview, questionnaire, rating scale, inventory, check list, content analysis; Tools of data analysis and decision-making Reliability and validity of tools.	15
IV	Basics of communication skills, types of scientific communication, structure of a research paper; principles of report writing and guidelines according to style manuals, writing and presentation of preliminary, main body and reference section of report, picture and graphs, evaluation of research report; characteristics of scientific writing and guidelines of style manual, effective illustration, reference style and presentation of scientific papers and synopsis.	15

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

References

1. Christian Tiberius, Hans van der Marel, René Reudink & Freek van Leijen (2021) Surveying and Mapping. Publisher: TU Delft OPENTU Delft Open TextbookDelft University of Technology — The Netherlands. ISBN (e-book): 978-94-6366-489-9. DOI: https://doi.org/10.5074/T.2021.007.
2. Gautam, N.C. (2004) Development of Research tools, Shree Publishers, New Delhi
3. Gupta Santosh (2005) Research Methodology and Statistical Techniques, Deep and Deep Publications.
4. Kothari C R, Research Methodology (Methods and Techniques) New Age Publications.
5. Panneerselvam, R., Research Methodology, Prentice Hall of India, New Delhi.
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7. Williams H Roy. Earth Science New Methods and Studies (2021). (Eds) Apple Academic Press. ISBN 9781774631874

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			✓
CO2	✓	✓	✓			✓
CO3		✓	✓	✓	✓	✓
CO4				✓	✓	✓

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLY DRC02	Research Ethics	2	-	2

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Understand the basics of philosophy of science and ethics, research integrity, publication ethics.	Understand
CO2	Guide in presenting plagiarism tools for a valid and ethical research report, Indexing and citation databases, open access publications, research metrics.	Understand

b. Syllabus

Units	**Content**	**Hrs.**
I	Definition of research ethics; confidentiality in maintaining the analysis data; scientific misconduct in research practice; essential ethical principles for research students, plagiarism, falsification, fabrication; Redundant Publications: duplicate and overlapping publications, salami slicing; selective reporting and misinterpretation of data. Definition, introduction, and importance of publication ethics; Conflicts of interest, authorship and contributor-ship, publication misconduct and violation of publication ethics; identification of predatory publishers and journals.	15
II	Introduction to open access publication; introduction to software tools to identify predatory publications and journal suggestion tools like Elsevier Journal Finder, Springer, Journal Suggester, etc.; use of plagiarism software like Turnitin, Urkund and other open-source software tools; introduction to Indexing databases, citation databases and research metrics. Impact factors, h-index, i10 index, and altmetrics	15

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments

✓ Seminars

✓ Class Tests

References

1. Nicholas H. Steneck. Introduction to the Responsible Conduct of Research. Office of Research Integrity. 2007.
2. Ethics in Science Education, Research and Governance Edited by Kambadur Muralidhar, Amit Ghosh Ashok Kumar Singhvi. Indian National Science Academy, 2019.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1					✓	✓
CO2	✓		✓	✓	✓	

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLY DRC03	Analytical Techniques in Geosciences and Seminar	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Analyse and interpret various geochemical data using common geochemical analytical techniques	Apply
CO2	Understand the principles of statistical analysis in geosciences	Understand
CO3	Use computer software and programing language for geological data interpretation	Analyse
CO4	Communicate their research findings with the scientific community	Evaluate

b. Syllabus

Units	Content	Hrs.
I	Introduction to principles of common geochemical analysis techniques; X-Ray diffraction (XRD), X-Ray Fluorescence (XRF) & Scanning Electron Microscopy (SEM) and its applications.	15
II	Statistical methods; standard deviation; skewness and kurtosis; scatter diagrams; frequency distribution; histogram; correlation, covariance, correlation coefficient and regression. Chi square distribution; probability; students 't' test, 'f' test; confidence interval, analysis; calculation of variance-covariance, simple linear models; cluster analysis.	15
III	Hands on basic computer skills MS Word, Excel, PPT, Origin, CorelDRAW. Basic idea of the use of Python for statistical analysis.	15
IV	Application of geospatial technology in earth sciences. Assignments and Seminar presentation based on scholar's area of interest	15

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

References

1. Potts, P. J. (2012). A handbook of silicate rock analysis. Springer Science & Business Media.
2. Gill, R. (2014). Modern Analytical Geochemistry: an introduction to quantitative

chemical analysis techniques for Earth, environmental and materials scientists. Routledge.
3. Merriam D.F., (Ed.) (2000). Computer Methods in the Geosciences, Elsevier.
4. Davis, J. C., (2002) Statistics and data analysis in geology, third edition, John Wiley & Sons, Singapore.
5. Simon W., (2000) Houlding Geostatistics: Modeling and Spatial Analysis, Springer: Har/CdrEdition (8 June 2000), CD-ROM: 161 pages, 2000.
6. Hohn, M.E. (1988) Geostatistics and Petroleum Geology, New York: Van Nostrand Reinhold,
7. Ott, R. L. & Longnecker, M (2015) An introduction to statistical methods & data analysis, Cengage Learning, USA.
8. Lutz, M, (2013) Learning Python, O'Reilly Media, Inc., USA.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3		✓	✓		✓	✓
CO4				✓	✓	✓

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLY SRC01	Geospatial Technology and Modelling in Groundwater Resources	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Provide scholars with the fundamental knowledge of Geospatial Technology and its application in groundwater resources.	Understand
CO2	Handling the remote sensing and GIS software	Analyse
CO3	Groundwater Exploration	Evaluate
CO4	Groundwater modelling and assessment	Evaluate

b. Syllabus

Units	**Content**	**Hrs.**
I	The fundamental concept of remote sensing - EMR (Electro-Magnetic Radiation) and its interaction with earth's surface and atmosphere, spectral bands and its characteristics; Digital Image Processing – Radiometric correction, Geometric correction, Noise removal, Edge detection, spatial filters. GNSS, GIS – Data model and its application	15
II	Hydrological Properties of Rocks: Porosity, Permeability, Specific Yield and Specific Retention, Base Flow, Transmissivity and Storage Coefficient - Hydraulic Conductivity – Aquifers: Types - unconfined, confined, leaky and perched aquifers: Darcy's Law: Validity of Darcy's Law - Ground Water Flow Equations: Steady, Unsteady and Radial Flow: Surface water quality and quantity assessment: Graphical Representation and Interpretation of Water Quality Data	15
III	Drilling Methods for Groundwater Bore Wells, Tube wells. Problems are due to the over-exploitation of groundwater, hard rock aquifer systems. Measurement of aquifer properties (Hydraulic Conductivity Transmissivity, Storativity) in different geological environments.	15
IV	Remote sensing, GIS and GNSS for groundwater exploration with case studies. Outline of methods of groundwater exploration - Groundwater provinces of India and Tamil Nadu. Groundwater modelling and its application. Groundwater Assessment including water budget.	15
Tasks and Assignments: Each student is required to undergo the following: ✓ Assignments		

✓ Seminars
✓ Class Tests

References

1. Anbazhagan. S, Venkatachalapathy, R. Neelakantan, R 2009. Exploration Geology and Geoinformatics, 1st Edition, Macmillan India Ltd., ISBN: 10:0230-63867-8
2. Jensen, J. R. (2005): Introductory Digital Image Processing, Prentice-Hall, New Jersey
3. Joseph, G. (2004): Fundamentals of Remote Sensing, Universities Press, Hyderabad, India
4. Lillesand, T. M., Kiefer, R. W. and Chipman, J. W. (2008): Remote Sensing and Image Interpretation, John Wiley & Sons, New Delhi
5. Sabins, Floyd F. Jr., 1997: Remote Sensing: Principles and Interpretation, W.H.Freeman, New York.
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c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	
CO2		✓	✓		✓	✓
CO3		✓	✓		✓	✓
CO4				✓	✓	✓

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLY SRC02	Advances in Structural Geology	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Explain the stresses acting in the earths and its resultant deformation, explain concept of strain and its significance.	Understand
CO2	Analyse the tectonics in brittle and ductile regime and relationship between deformation and crystallisation.	Analyse
CO3	Explain the meso and micro-deformation and construct the retrodeformation.	Apply
CO4	Analyse the petrofabric elements, paleo-earthquake deformation and the theory of plate tectonics	Apply

b. Syllabus

Units	**Content**	**Hrs.**
I	Mechanical properties of rocks; Types, representation and role of stresses in rock deformation; Dynamics of faulting under different stress regimes; Strain ellipsoids, Techniques of Strain analyses.	15
II	Thin- and thick-skinned tectonics; Thrust Geometry and Fault-related folds; Relation between Deformation and Crystallisation, Detailed analysis of Shear zone.	15
III	Crystallographic and Lattice preferred orientation of minerals and their implications; Penetrative and non-penetrative fabrics and their use in structural analyses; Analysis of meso and microscopic structures in deformed rocks; Concept of Balanced Cross Section.	15
IV	Petrophysical properties of rocks; Petrofabric analyses; Paleoseismology; Application of Anisotropy of Magnetic Susceptibility in fabric analysis of rocks; Plate tectonics and geodynamics of plate boundaries	15

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments

✓ Seminars

✓ Class Tests

References

1. Ghosh, S.K. (1993). Structural Geology: Fundamentals and Modern Developments. Pergamon Press.

2. Jayangondperumal, R. Thakur, V.C., Vivek, J., Priyanka, R.S. and Gupta, A.K. (2018). Active Tectonics of Kumaun and Garhwal Himalaya, 151 pp. Springer Natural Hazard Series.
3. Marshak, S. and Mitra, G. (1988). Basic Methods of Structural Geology. Printice Hall.
4. Ramsay, J.G. (1967): Folding and fracturing of rocks. McGraw Hill.
5. Ramsay, J.G. and Huber, M.I. (1983). Techniques of Modern Structural Geology, Vol. I, Strain Analysis. Academic Press.
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c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			✓
CO2	✓	✓	✓			✓
CO3		✓	✓		✓	✓
CO4		✓	✓		✓	✓

SEMESTER - I				
Course Code	**Course Name**	**L**	**P**	**Credits**
GLY SRC03	Applied Geochemistry	4	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	**Level**
CO1	Understand the geochemical behavior of elements in various reservoirs of the Earth and their interaction with different environmental components.	Understand
CO2	Explain the principles of geochemistry to understand the behavior of various elements in aquatic and sedimentary environments.	Analyse
CO3	Apply the geochemistry of rocks and minerals in mineral exploration and petrogenesis.	Apply
CO4	Demonstrate the relationship between geological processes and health risks associated with humans, animals and plants	Apply

b. Syllabus

Units	**Content**	**Hrs.**
I	Introduction to the chemical composition, properties and evolution of various reservoirs of the Earth. Classification, mineralogy, origin and significance of meteorites. Geochemical classification of elements. Element partitioning in mineral/rocks formation and concept of distribution coefficient. The applications of trace elements in the petrogenesis. Introduction to radioactivity, geochronology and isotopic mass fractionation. Radiogenic and stable isotopic systematics. Decay scheme of K–Ar, Ar–Ar, Rb–Sr, Sm–Nd and U–Th–Pb systems. Stable isotope geochemistry of carbon, oxygen, hydrogen, sulphur and its applications in petrology and paleoclimatology.	15
II	Geochemistry of natural waters, water quality, water sampling techniques, analytical methods in hydro chemical studies, interpretation of physical and chemical data of water, graphical representation methods in presenting hydro chemical data. Introduction to sediment geochemistry, Geochemical processes involved in rock weathering and soil formation.	15
III	Distribution of elements in the Earth crust, primary and secondary dispersion of elements, controls of dispersion, mobility of elements, geochemical association of elements, application of pathfinder elements in mineral exploration, determination of geochemical anomaly, background and threshold value, geochemical survey methods, geochemical sampling techniques- litho-geochemical sampling, pedo-geochemical sampling, atmo-geochemical sampling, heavy mineral sampling and biogeochemical sampling.	15

	Interpretation of geochemical data in mineral exploration.	
IV	Fundamentals of agricultural geochemistry, sources of trace elements and metals in soils, pollution assessment in soils, health effects associated with toxicity/deficiency of various elements in plants and crops. Definition, concepts and history of medical geology, chemical constituents of the human body, essential elements and toxic elements, dose-response curve. Geophagy and health benefits of geologic materials. Geologic sources of health risks – fluorosis, silicosis, arsenicosis, iodine deficiency diseases (IDD), Radon hazards, heavy metal poisoning and nitrate contamination in ground water.	15

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

References

1. Clark, I. (2015). Groundwater geochemistry and isotopes. CRC press.
2. Dissanayake, C. B., & Chandrajith, R. (2009). Introduction to Medical Geology. Erlangen Earth Conference Series. Springer.
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6. Levinson, A. A. (1980). Exploration geochemistry. Applied Publishing, Wilmette, IL.
7. Moon, C., Whateley, M., & Evans, A. (2005). Introduction to mineral exploration. Wiley-Blackwell.
8. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
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10. Selinus, O. (2013). Essentials of medical geology: revised edition. Springer.
11. White, W. M. (2020). Geochemistry. John Wiley & Sons.
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c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			✓
CO2	✓	✓	✓			✓
CO3	✓	✓	✓			
CO4	✓	✓	✓	✓		✓

SEMESTER - I					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
GLYSRC04	Geomechanics	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Explain various concepts of rock mechanics and geomechanics used in various engineering projects	Understand
CO2	Study rock failure mechanism, rock mass classifications and the concept of rock slope engineering, landslide study	Apply
CO3	Analyse the concept of flow of fluids in porous media and wellbore stability	Analyse
CO4	Evaluate the importance of geomechanics in varius conventional and unconventional engineering projects	Evaluate

b. Syllabus

Units	Content	Hrs.
I	Basic principles of geomechanics and its application. Concept of stress-strain-deformation in reservoir. Physical, mechanical properties of rocks and their significance; Mohr's circle of stress and strain and theories of rock failure mechanics.	15
II	Discontinuities in rock masses. Concepts of rock mass classification. Geological and geomechanical consideration for evaluation of sites for engineering projects, Rock slope engineering, and Landslide's investigation.	15
III	Fluid flow in porous media and constitutive laws; stress around vertical, horizontal, and deviated wells; Determination of in-situ stresses. Wellbore failure and stress determination in deviated wells. Wellbore stability; cap rock integrity,	15
IV	Reservoir compaction and subsidence; hydraulic fracturing; geomechanics of unconventional hydrocarbon reservoirs; geomechanics of carbon storage and enhanced oil/gas recovery; induced seismicity and risks.	15

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments

✓ Seminars

✓ Class Tests

References

1. Deb, D., Verma, A.K. (2016). Fundamental and applications of rock mechanics. PHI Learning Private Limited.

2. Jaeger, J.C., Cook, N.G.W., Zimmerman, R.W. (2007). Fundamental of rock mechanics. Blackwell Publishing Ltd.
3. Singh, B., Goel, R.K. (2011). Engineering rock mass classification. Elsevier Inc.
4. Zoback, M.D. (2010) Reservoir Geomechanics, Cambridge University Press.
5. Zoback, M., & Kohli, A. (2019). Unconventional Reservoir Geomechanics: Shale Gas, Tight Oil, and Induced Seismicity. Cambridge, Cambridge University Press.
6. Ahmed, T. & McKinney, P. D. (2005). Advanced Reservoir Engineering, Gulf Professional Publishing.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓			✓
CO3	✓	✓	✓			✓
CO4	✓	✓	✓	✓		✓

SEMESTER - I					
Course Code	**Course Name**	**L**	**T**	**P**	**Credits**
GLYSRC05	Hazards and Risk Impact Assessment	4	-	-	4

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Describe common natural hazards and their impact on human settlements and natural systems.	Understand
CO2	Apply critical thinking approach to development of new risk reduction policies. Evaluate the common methods used to mitigate and prepare for each type of hazard event.	Apply
CO3	Describe Risk Impact Assessment (RIA) and Risk Management.	Evaluate
CO4	Examine Hazard, Risk, Vulnerability, & Capacity (FIRVC) analysis in sectoral applications.	Evaluate

b. Syllabus

Units	Content	Hrs.
I	Introduction to natural and anthropogenic hazards-Definitions of natural and anthropogenic hazards; Type of natural and anthropogenic hazards; Geophysical Hazards-Intro to geophysical hazards (e.g., earthquake, volcanic eruption, rock fall, landslide, avalanche, and subsidence); Introduction to methods for analysing geophysical hazards.	15
II	Hydrometeorological hazards-Introduction to hydrometeorological hazards (e.g., flood, drought, storm, extreme temperature, wildfire, and wet mass movement); Introduction to methods for analysing hydrometeorological hazards. Biological hazards-Introduction to biological hazards (e.g., epidemic, insect infestation, and animal stampede): Introduction to methods for analysing biological hazards.	15
III	Introduction to risk assessment-Introduction to disaster risk management and risk assessment; Hazard Assessment-Hazard types; Main concepts of hazard assessment; Frequency magnitude – relationships; Vulnerability assessment-Types of vulnerability; social vulnerability; physical vulnerability; methods for vulnerability assessment; participatory GIS; Spatial Multi Criteria Evaluation.	15
IV	Elements at risk assessment-Types of elements at risk; classification of buildings, infrastructure, lifelines, critical facilities; population information; collection of elements at risk information; Risk assessment-Loss estimation models; HAZUS; qualitative risk assessment; QRA; basics of flood risk, seismic risk, landslide and technological risk assessment; Risk management-	15

	Risk evaluation; risk governance; risk communication; cost benefit analysis; Using risk information for emergency planning; spatial planning and Environmental Impact Assessment.	

Tasks and Assignments:

Each student is required to undergo the following:

✓ Assignments
✓ Seminars
✓ Class Tests

References

1. Alexander, D. E. (2013). Resilience and disaster risk reduction: An etymological journey. Natural Hazards and Earth System Sciences Discussions, 1(2), 1257-1284. https://doi.org/10.5194/nhessd-1-1257-2013
2. Below. R. &Wallemaca. P. (2018). Annual disaster statistical review 2017. CRED, Centre for Research on the Epidemiology of Disasters.
3. Change, I. P. 0. C. (2007). Climate change 2007: the physical science basis: summary for policymakers. Geneva: IPCC.
4. Coppola, D. P. (2006). Introduction to international disaster management. Elsevier. ISBN: 9780080465739
5. O'Brien, G., O'Keefe, P., Rose, J., & Wisner, B. (2006). Climate change and disaster management. Disasters, 30(1), 64-80. https://doi.org/10.1111/j.1467-9523.2006.00307.x
6. Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G., &Rockström, J. (2006). Reducing hazard vulnerability: Towards a common approach between disaster risk reduction and climate adaptation. Disasters. 30(1), 39-48. https://doi.org/10.1111/j.1467-9523.2006.00305.x
7. Multi Hazards Risk Assessment – Theory Book, C.J. van Western (end), D. Alkema, M.C.J. Damen, N, Kerle, and N.C. Kindma, United Nations University – ITC School on Disaster Geoinformation Management (UNU-ITC DGIM), Version 2011.
8. Multi Hazards Risk Assessment – Exercise Book, C.J. van Western (end), D. Alkema, M.C.J. Damen, N, Kerle, and N.C. Kindma, United Nations University – ITC School on Disaster Geoinformation Management (UNU-ITC DGIM), Version 2011.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			✓
CO2	✓	✓	✓		✓	✓
CO3			✓	✓	✓	
CO4				✓	✓	✓