



# Course Specification

Diploma

Course Title: Exploration Geophysics II

Course Code: APQM3212

Program: Mining and Quarrying

Department: Diploma Department

College: The Applied College

Institution: Umm Al-Qura University

Version: 1

Last Revision Date: 20 February 2025



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## A. General information about the course:

### 1. Course Identification

1. Credit hours: ( 3 )

#### 2. Course type

A. ☐ University ☐ College ☒ Department ☐ Track ☐ Others  
B. ☒ Required ☐ Elective

3. Level/year at which this course is offered: ( 1 St. Level)

#### 4. Course General Description:

##### 1. Course Description

Exploration Geophysics course typically focuses on applying geophysical methods to explore subsurface structures and resources like minerals, oil, natural gas, water, and even environmental investigations. Geophysics is a critical tool in geoscience, where non-invasive techniques are used to study the Earth's subsurface.

This course explores the principles, instrumentation, and applications of electromagnetic (EM) methods used in geophysical investigations. Students will gain theoretical knowledge and hands-on experience in EM techniques, including time-domain and frequency-domain EM, magnetotellurics, and very low frequency (VLF) methods. Real-world applications in groundwater exploration, environmental surveys, and mineral prospecting will be emphasized.

course covers the theory, instrumentation, data acquisition, processing, and interpretation of Ground Penetrating Radar (GPR) in near-surface geophysics. Emphasis is placed on practical applications in environmental site characterization, civil infrastructure, archaeology, and hydrology. The course includes both classroom lectures and hands-on field and lab work.

ocuses on the principles, instrumentation, and applications of radioactivity-based geophysical methods. Topics include natural and artificial radioactivity, gamma-ray spectrometry, radon surveys, neutron activation, and nuclear well logging techniques. The course emphasizes the use of radiometric data in mineral exploration, environmental monitoring, hydrogeology, and geological mapping.

#### 5. Pre-requirements for this course (if any):

Exploration Geophysics I

#### 6. Co-requisites for this course (if any):

None

#### 7. Course Main Objective(s):



- Understand the physical principles of EM fields and their interaction with the Earth.
  - Differentiate between various EM survey methods.
  - Design and conduct EM surveys using field equipment.
  - Process and interpret EM data using software tools.
  - Apply EM methods to real-world geoscientific and engineering problems.
  - Understand the physical principles governing GPR signal propagation and reflection.
  - Explain how soil properties affect GPR signal behavior.
  - Conduct GPR surveys using appropriate equipment and configurations.
  - Process raw GPR data using commercial and open-source software.
  - Interpret GPR profiles to identify subsurface features.
  - Apply GPR techniques to solve real-world problems in engineering, environmental, and archaeological contexts.
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- Understand the fundamental physics of radioactive decay and nuclear interactions.
  - Identify natural sources of radiation and their geophysical significance.
  - Use field instruments for measuring gamma radiation, radon, and neutron flux.
  - Interpret radiometric data in geological and environmental contexts.
  - Apply radiometric techniques in resource exploration and hazard assessment.
  - Evaluate the safety, regulations, and ethical issues in radioactive surveys.

## 2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	60	100%
2	E-learning		
3	Hybrid <ul style="list-style-type: none"> <li>• Traditional classroom</li> <li>• E-learning</li> </ul>		
4	Distance learning		

## 3. Contact Hours (based on the academic semester)





No	Activity	Contact Hours
1.	Lectures	30
2.	Laboratory/Studio	30
3.	Field	
4.	Tutorial	
5.	Others (specify)	
Total		60

## B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

1.0	Knowledge and understanding			
1.1	<ul style="list-style-type: none"> <li>Understand the physical principles of EM fields and their interaction with the Earth.</li> <li>Differentiate between various EM survey methods.</li> <li>Design and conduct EM surveys using field equipment.</li> </ul>	K1	Lectures and Interactive Discussions	Written Exams (Mid-Term and Final Exams), Quizzes.
1.2	<ul style="list-style-type: none"> <li>Understand the physical principles governing GPR signal propagation and reflection.</li> <li>Explain how soil properties affect GPR signal behavior.</li> </ul>	K3	Lectures and Interactive Discussions	Written Exams (Mid-Term and Final Exams), Quizzes.
1.3	<ul style="list-style-type: none"> <li>Conduct GPR surveys using appropriate equipment and configurations.</li> <li>Process raw GPR data using commercial and open-source software.</li> </ul>	K2	Lectures and Interactive Discussions	Written Exams (Mid-Term and Final Exams), Quizzes.
	<ul style="list-style-type: none"> <li>Interpret GPR profiles to identify subsurface features.</li> </ul>	K4	Lectures and Interactive Discussions	Written Exams (Mid-Term and Final Exams), Quizzes.
2.0				
2.1	<ul style="list-style-type: none"> <li>Apply GPR techniques to solve real-world problems in engineering, environmental, and archaeological contexts.</li> <li>Understand the fundamental physics of radioactive decay and nuclear interactions.</li> </ul>	S1	Interactive Discussions	Written Exams (Mid-Term and Final Exams), Quizzes
2.2	<ul style="list-style-type: none"> <li>Identify natural sources of radiation and their geophysical significance.</li> <li>Use field instruments for measuring gamma radiation, radon, and neutron flux.</li> </ul>	S3	Interactive Discussions	Written Exams (Mid-Term and Final Exams), Quizzes





3.2	<ul style="list-style-type: none"> <li>• Interpret radiometric data in geological and environmental contexts.</li> <li>• Apply radiometric techniques in resource exploration and hazard assessment.</li> <li>• Evaluate the safety, regulations, and ethical issues in radioactive surveys.</li> </ul>	S4	Interactive Discussions	Written Exams (Mid-Term and Final Exams),
3.0	Values, autonomy, and responsibility			
3.1	<ul style="list-style-type: none"> <li>• Process and interpret EM data using software tools.</li> <li>• Apply EM methods to real-world geoscientific and engineering problems.</li> </ul>	V1	Individual and Group Presentations	Presentations

### C. Course Content

No	List of Topics	Contact Hours
1.	Introduction to Electromagnetic Geophysics & Review of Maxwell's Equations Electrical Properties of Earth Materials: Conductivity, Permittivity, Permeability	2
2.	Natural Source EM Methods: Magnetotellurics (MT), Audio-Magnetotellurics (AMT) Controlled Source EM – Frequency Domain (FDEM): Loop-loop and Slingram	2
3.	Controlled Source EM – Time Domain (TDEM): Transients and diffusion Instrumentation and Survey Design (FDEM/TDEM) EM Signal Processing Techniques: Filtering, stacking, deconvolution	
4.	Field Techniques – Ground EM Surveys (FDEM) Field Techniques – TDEM Survey Demo Inversion and Interpretation of EM Data VLF (Very Low Frequency) Methods and Radiowave Propagation Airborne EM Surveys and Remote Sensing Applications Case Studies in Environmental and Mineral Exploration	2
5.	Introduction to GPR: History, Applications, Advantages & Limitations Electromagnetic Wave Theory and Radar Principles Dielectric Properties of Subsurface Materials	2
6.	GPR Equipment and Survey Design: Antennas, Frequencies, and Acquisition Parameters Data Acquisition Techniques: Line, Grid, and 3D Surveys GPR in Different Environments: Soil, Rock, Pavement, and Concrete	2





7.	Field Data Collection I: Setup, Operation, and Real-time Observation Data Processing I: Time-zero correction, filters, gain functions Data Processing II: Migration, deconvolution, attribute analysis 1GPR Interpretation I: Hyperbolas, layer boundaries, and anomalies	2
8.	GPR Interpretation II: Feature mapping and volumetric analysis	2
9.	Field Data Collection II: Advanced Applications (e.g., void detection, rebar mapping) Case Studies: Archaeology, Utility Detection, Environmental and Engineering Uses	2
10.	Introduction to Radiometric Geophysics: History, Scope, Applications	2
11.	Basics of Nuclear Physics: Radioactive Decay, Isotopes, Units of Measurement Natural Radioactivity: Potassium (K-40), Uranium (U), and Thorium (Th)	2
12.	Gamma-Ray Spectrometry – Theory and Detection Mechanisms Gamma-Ray Spectrometry – Field Equipment, Calibration, Resolution Ground Gamma-Ray Surveys – Data Collection & Mapping Techniques Airborne Radiometric Surveys – Principles and Processing	2
13.	Radon Detection and Mapping – Environmental and Hydrogeological Applications	2
14.	Neutron Logging & Activation Methods – Borehole Applications Nuclear Well Logging Techniques – Gamma-Gamma, Neutron-Neutron, Spectral Logging	2
15.	Data Processing – Spectral Analysis, Filters, Calibration Techniques Case Studies – Uranium and Thorium Exploration, Soil Mapping, Contamination Studies Radiometric Surveys in Archaeology, Hydrology, and Engineering Radiation Safety, Regulations, and Environmental Impact	2
<b>Total</b>		<b>30</b>

## C.2 Experimental Content

No	List of Topics	Contact Hours
1.	Introduction and Field Safety Procedures	2
2.	Measuring Electrical Properties of Soils ( $\sigma$ , $\epsilon$ , $\mu$ )	2
3.	Electromagnetic Survey Using FDEM	2
4.	TDEM Survey (Time-Domain Response)	2
5.	Design and Execution of EM Field Survey (FDEM/TDEM) EM Data	2
6.	Processing (Filtering, Stacking)	2





7.	GPR Operation and Linear Survey Setup	2
8.	GPR in Different Environments (Soil, Concrete)	2
9.	GPR Data Processing I (Time-zero, Gain Adjustment)	2
10.	GPR Interpretation I (Hyperbolas, Layers)	2
11.	Natural Radiation Measurement (K, U, Th)	2
12.	Radon Detection and Analysis	2
13.	Radiometric Spectral Data Analysis	2
14.	Final Integrated Field Activity & Review	2
<b>Total</b>		<b>28</b>

## D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Quizzes	5	10
2.	Mid-Term Exam	8	20
3.	Presentations	12	10
4.	Homework	All weeks	10
5.	Final Exam	16	50

\*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

## E. Learning Resources and Facilities

### 1. References and Learning Resources

#### Essential References

"Introduction to Applied Geophysics" by Charles M. Kearey, Michael Brooks, and Ian Hill

A very comprehensive book that covers the fundamental principles of exploration geophysics with practical examples. Great for beginners and intermediate students.

"Environmental and Engineering Geophysics" by John M. Reynolds  
A textbook that emphasizes geophysical methods in environmental and engineering applications, including groundwater studies and site investigations.







<b>Supportive References</b>	<p>"The Solid Earth: An Introduction to Global Geophysics" by C.M.R. Fowler Offers a broader view of geophysics, covering global Earth structures and their relation to exploration techniques.</p> <p>"Practical Geophysics" by S. L. Uyeshima and D. P. L. S. G. S. T. R. Focused on practical, field-based applications and problem-solving. Excellent for those interested in field surveys and hands-on data collection.</p>
<b>Electronic Materials</b>	
<b>Other Learning Materials</b>	

## 2. Required Facilities and equipment

Items	Resources
<b>facilities</b> (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Classrooms
<b>Technology equipment</b> (projector, smart board, software)	Data show
<b>Other equipment</b> (depending on the nature of the specialty)	

## F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Faculty	Direct (project, HW, Quiz, midterm and final exam)
Effectiveness of Students assessment	Students	Indirect (Student Survey)
Quality of learning resources	Program Coordinator	Direct analysis
The extent to which CLOs have been achieved	Program Coordinator	Direct analysis
Other		

**Assessors** (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify))

**Assessment Methods** (Direct, Indirect)

## G. Specification Approval

<b>COUNCIL /COMMITTEE</b>	Umm Al-Qura University Council
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REFERENCE NO.	851110214476/195605
DATE	18/2/1447

