



Electrical and Electromagnetic Methods

Cross-listed as an undergraduate (GEOL 4816) and a graduate course (GEOL 5816)

Winter (January 6 – May 2) 2025

Harquail School of Earth Sciences (HES)

Laurentian University

Course Description: This course covers electrical (self potential, resistivity and induced polarization) and electromagnetic methods, including a discussion of the relevant physical properties, the background theory (Maxwell's equations), instrumentation and procedures to collect the data. Students will learn methods for processing, displaying and interpreting the data using qualitative methods and forward and inverse modelling methods. Case history examples, including searching for mineral deposits will be discussed.

Prerequisites: Completion of 30 university credits which include GEOL 1006/1007; PHYS 1006 /1007; MATH 1036 or 1912. Recommended MATH 2037. Students cannot retain credits for both GEOL 4816 and GEOL 5816. (lec 3, lab 3) cr 3.

Course Instructor: *Dr Richard Smith* (Harquail School of Earth Sciences/MERC), Willet Green Miller Building, Room B8018, (705) 675 1151 ext 2364. Email: rsmith@laurentian.ca.

Office hours: Tuesday 2:30 to 4 pm and Wednesday 11:30 am to 1:00 pm. Appointments can be made via email.

Course Format: lectures Tuesday 4:00 – 6:50pm, B8030, laboratory practicals/exercises Wednesday 1:00 – 3:50 pm, B8030.

Remote and asynchronous participation will be possible in this course as all material (lectures, discussion documents, textbooks) are available at any time.

Course Credit: 3 credits towards an undergraduate or graduate degree. Successful completion of the course can be counted toward continuing education and continuing professional development requirements for professional registration. A participation certificate will be issued on request with hours listed.

Assessment:	Assessment Type	Number	Overall Weight (%)	Participation certificate
	Generating quiz questions	8	20	Required
	Laboratory reports	3	15	Not required
	Class discussion documents	8	20	Required
	Presentation a chapter	1	20	Not required
	Summative exercise (in lieu of exam)	1	25	Not required

The quiz questions are 5 multiple choice questions that you generate for each chapter of the student authored textbook to test your understanding of the material. The laboratory reports are reports on the data acquisition, processing, display and interpretation of the data we collect on campus. Students in GEOL 5816 are expected to include something on modelling and interpretation as well. The class discussion documents are completed as each student reads each of the chapters *and* during the class discussion time. In the discussion, students highlight inadequacies in the material (errors, poor explanations, missing material, etc) and then the class suggests how to rectify the defects. The summative exercise involves each student revising one (or part of one) of the chapters, following the suggested modifications that have been contributed to the class discussion document.

A Presentation is given during the final week of class on a different chapter than the one that is being revised by that student.

Quizzes and contributions to the discussion documents should be completed at the end of the week that the discussion of the relevant chapter is completed, for example, for the introductory chapter, this is Sunday **January 19** at 11:59 pm.

Chapter Discussions: A set of chapters from a student-authored textbook will be provided. The students are to discuss this chapter, indicating errors, outlining topics that are missing from the chapter or concepts or text they do not understand. This discussion will take place by editing a document on Google Drive using Google Docs. Students will then be expected to find explanations for what they or other students do not understand and insert this in the relevant Google Doc. Students can also make suggestions as to additional material to include in the chapter. For this they can draw on other textbooks, videos of lectures or the scientific literature. For grading, students are to upload their contributions to a Dropbox on D2L or if they do not have access to D2L email it to the instructor.

Summative exercise: Prepare and/or revise the chapter selected from the student-authored textbook. The revisions will be based on the discussion documents the class have prepared as part of the chapter discussions. If there are not many suggestions, case one or more case histories of the method being applied to an example should be taken from the open-source literature, or from the journals *Geophysics*, *Interpretation* or the *Leading Edge* and added to the chapter. A guide to writing the chapter is provided. For these chapters, in the discussion document, the students will suggest figures or slides from the lectures or textbooks that have been supplied that could be added to the chapter. Students should spend about 24 hours on this task. The revised chapter **is due at the end of the exam period.**

Website: Course materials and announcements will be posted on D2L (Desire 2 Learn) and/or the Google Drive for the course. Announcements will be emailed to participants without access to D2L. It is the student's responsibility to check the D2L page or their email account for course information throughout the semester.

Course Costs for Enrolled students: Undergraduate and graduate students from Laurentian can enroll using the usual channels. Graduate students enrolled in other Ontario universities will not pay fees directly to Laurentian, but their home institution, as they can enroll through the Ontario Visiting Graduate Student program. Undergraduate students outside Laurentian or graduate students from outside Ontario will need to obtain a *letter of permission* from their home institution to enroll in Laurentian and then they will pay fees to Laurentian. Students or professionals who are not taking the course for credit, but as professional development can enroll using the registration form for the course (see the registration section immediately below for how to request a registration form). Those *not* taking the course for credit are expected to take part in the discussions and generate quiz questions, but are not required to hand in material for assessment, although they can if they wish.

Course Costs for Professional participants: 1) In person attendance: CDN \$2750.00 (CDN) + 13% GST. 2) Remote (zoom) attendance: CDN \$1200 + 13% HST. Registration includes all digital course notes. Professionals working for MERC members get a discount in registration fees. **Registration:** Ms. Roxane Mehes, Harquail School of Earth Sciences, Laurentian University, 935 Ramsey Lake Road, Sudbury, ON P3E 2C6 Canada, Tel: +1 (705) 673-6575, Fax: +1 (705) 675-4898, e-mail: rmehes@laurentian.ca

Course textbooks and notes: Digital textbooks and lecture notes will be provided free of charge.

Further information about MERC courses may be found at: <http://hes.laurentian.ca/> under Modular Courses. For other information about the course please contact: rsmith@laurentian.ca

Course Learning Outcomes

Upon completion of this course students will be able to:

1. Understand the basic theory relevant to electrical and electromagnetic methods.
2. Describe the strength and weaknesses of various types of electrical and electromagnetic equipment, the governing physics, the quantities they measure and how these quantities depend on the physical properties of the subsurface geological material.
3. Design electrical and electromagnetic surveys and then know how to acquire, process and model and interpret the data to investigate the subsurface.
4. Present the results of electrical and electromagnetic surveys by displaying the results graphically and communicating the results in written documents and oral presentations.
5. Describe case histories where electrical and electromagnetic data is used to solve real-world problems in areas such as geology, planetary science, mineral exploration, environmental studies, archaeology, forensic science, agriculture and engineering.
6. Apply electrical and electromagnetic methods when working as a geoscientist in industry, government or academia.

Tentative schedule

Potential-field and gamma-ray spectrometry methods GEOL 4826 and 5826 Winter 2024

Week starting Monday	Chapter topic or lecture	Discussion	Laboratory	TA
Jan 6	Intro and physical properties lecture	Introduction to discussion documents	Continuation of introduction to discussion documents and chapter editing	
Jan 13	EM theory lecture	Discussion of Introduction chapter	Data acquisition LIN instrument	
Jan 20	Electrical methods I	Discussion of EM theory chapter	Write LIN report	
Jan 27	Electrical methods II	Discussion of Electrical chapter	Write LIN report	
Feb 3	Electromagnetic methods I	Discussion of Electrical Case Histories	Data acquisition MaxMin	
Feb 10	Electromagnetic methods II	Discussion of EM chapter	Write MaxMin Report	
Feb 17	<i>Study Break</i>	<i>Study Break</i>	<i>Study Break</i>	
Feb 24	Low induction number (LIN) methods	Discussion of EM case histories	Write MaxMin Report	
Mar 3	PDAC 2-6 March	No classes	No Lab	
Mar 10	Magnetotelluric (MT) methods	Discussion of LIN methods chapter	Data acquisition resistivity	
Mar 17	VLF methods	Discussion of MT chapter	Write Resistivity report	
Mar 24	Borehole methods	Discussion of VLF chapter	Write Resistivity report	
Mar 31	Discussion of Borehole Chapter	Final presentations	Final presentations	
April 4	<i>Final Day of classes</i>	<i>Friday April 4.</i>		

Quiz question exercise

Each student devises 5 multiple choice questions for each chapter. Creative and imaginative questions that can test a student's understanding will get better marks. Place an asterisk in front of the correct answer. This means you have to turn off automatic numbering of lists if you use a word processor. For example: In GEOL 4816/5816 Electrical and Electromagnetic methods, I will learn

- a) How electromagnetics can estimate the conductivity
- b) The pitfalls of the electroseismic method
- c) The meaning of the word "polarization"
- d) All of the above
- *e) Only a) and c)

The questions and answers will be awarded points for

- 1) correctness,
- 2) understandability of question,
- 3) understandability of answers
- 4) lack of ambiguity in answers, and
- 5) creativity or originality

If you use a figure or equation, you get zero marks.

Land Acknowledgment

We would like to acknowledge the Robinson-Huron Treaty of 1850. We also further recognize that Laurentian University is located on the traditional lands of the Atikameksheng Anishnawbek and that the City of Greater Sudbury, also includes the traditional lands of the Wahnapiatae First Nation. We extend our deepest respect to Indigenous peoples - as a sign of our continued relationship we will support Laurentian University's Truth and Reconciliation Task Force Recommendations. Miigwech.

Course policy on Artificial intelligence. It is permitted to use artificial intelligence like ChatGPT, Bing AI (and co-pilot), Bard, etc. to get a start on assignments; however, you are required to submit copies of all your questions to the AI and the responses of the AI, so please keep these and submit them separately as an appendix with your submission(s). Beware, that AI is general, vague, and often incorrect, so can be easy to identify. AI does not provide precise in line references and this is required in scientific writing. So far my experience is that AI does not provide useful content. For more details see <https://link.springer.com/article/10.1007/s10676-024-09775-5>.

Equity, Diversity and Inclusion: I seek to engender a class environment where equity, diversity and inclusion are embraced. Feedback on any of these matters is welcome and encouraged.

Final Grades:	The final grades will be consistent with the University Grading System. LU Grading Scheme For information regarding appeals of final grades or other academic matters please consult the university's intranet site. LU Grade Appeal Policy
Course:	Insert details on the course content here
Student Conduct:	Students will be expected to abide by the Laurentian University Code of Conduct. LU Code of Student Rights and Responsibilities
Academic Integrity:	In this course, students are expected to submit their own individual work for academic credit, properly cite the work of others, and to follow the rules for examinations. Academic misconduct, plagiarism, and cheating will not be tolerated. Copying of assignments and lab reports is considered academic misconduct. Students are responsible for understanding and following the Laurentian University Policy on Academic Integrity. LU Policy on Academic Integrity
Safety:	The Faculty of Science, Engineering and Architecture takes safety very seriously. Students are expected to work in a safe manner, follow all safety instructions, and use any personal protective equipment required/provided. Students failing to observe the safety rules in any laboratory will be asked to leave.