

# 1 Introduction

## 1.1 Instructors

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## 1.2 Course description

The course description for GEOL 319 in the Applied Science Calender is:

Techniques of geophysics (including gravity, magnetic, electrical, and seismic) applied to engineering problems, including resource exploration and site investigation. Physical principles, instrumentation, field procedures, data interpretation, and design of field programs are covered for each of the major methods.

Pre-requisites (Applied Science): GEOL 249 (Geophysical characterization), MATH 226 (Ordinary differential equations), MATH 227 (Vector analysis), *or permission of the instructor.*

In the Arts and Science Calender the course description is the same, but the pre-requisites are:

GEOL 111 (Principles of Geology - or equivalent), MATH 121 (Differential and integral calculus), MATH 221 (Vector calculus), and GEOL 249 (Geophysical characterization), *or permission of the instructor. A knowledge of differential equations (MATH 232) would be an asset.*

The course is also offered in the Graduate Calender as GEOL 829 (primarily for students in the Mineral Exploration graduate program), in which case the lecture material is the same, but additional tutorials and a short, three day field component is included. The description in the Graduate Calendar for GEOL 829 is

A graduate level, introductory course in applied geophysics (including gravity, magnetic, electrical and seismic methods) for resource exploration and site investigation. Physical principles, instrumentation, field procedures, data interpretation, design of field programs and case studies are covered for each of the major methods.

## 1.3 Other geophysics courses at Queen's

**Geology 249:** Geophysical characterization of the Earth. An introductory course in geophysics covering the geophysical characterization of the earth at all scales. The physical properties and dynamic processes are assessed and an introduction to applied geophysical methods is provided. Winter term.

**Geology 349:** Applications of quantitative analysis in geological engineering. Geophysics is only one aspect of this course, which teaches mathematical and programming methods in the solution of practical problems in geological engineering. Winter term.

**Geology 409:** Applied geophysics laboratory: This is the continuation of Geology 319, providing hands-on experience with a variety of geophysical field methods. A one week field survey is designed and carried out by the students. This course is core for geophysical engineers, and is a technical elective for all other students in geological engineering. Fall term, alternate years.

**Geology 429:** Geophysical signal analysis. Covers the major processing tools used to analyze geophysical data (gravity, magnetic and seismic). Theory and practice, including discrete linear and non-linear problems, inverse methods, uniqueness and accuracy. Winter term, alternate years.

**Geology 479:** Potential field and electromagnetic methods. An advanced course dealing with the application of gravity, magnetic, electromagnetic, resistivity, and induced polarization methods. Winter term, alternate years.

**Geology 489:** Seismic methods: An advanced course dealing with the analysis, modelling and processing of controlled source seismic data. Winter term, alternate years.

## 1.4 Course Structure

The course is divided into three consecutive blocks, covering

1. Gravity and magnetic field methods (chapters 2 and 3),
2. Electrical and electromagnetic methods (chapters 4 and 5), and
3. Seismic methods (chapter 6).

Each topic will follow a similar plan, covering the basic physical principles of the measurement, the instrumentation and field methods used, the methods used for data reduction, the interpretation of the results, and a series of case studies illustrating applications. The table of contents (above) is a guide to the detailed lecture plan for the course.

## 1.5 Assessment

Performance in this course will be assessed on the basis of approximately 6 problems sets, a mid-term exam and a final exam. Problem sets will be assigned every two weeks, usually due within a week of distribution. We will attempt to mark and return these within a week. These problem sets will re-enforce lecture material and prepare you for the questions that will be set on the final exam. I suggest the following breakdown for assessment in this course:

	GEOL 319	GEOL 829
Assignments	25%	20%
Mid-term exam	15%	15%
Final exam	55%	40%
Field project	-	25%
Class participation, quizzes, etc (occasional)	5%	5%

## 1.6 Textbook(s)

I recommend you buy *one* of these books:

*Telford, W.M., Geldart, L.P, and Sheriff, R.E. Applied Geophysics, Second Edition. Cambridge University Press, 1990.* (Suitable for students specializing in Geophysics. In the past this was considered a very complete reference textbook, but it is becoming somewhat dated. In sections it tends to be overly mathematical, but it does have many examples of geophysical data in a wide range of applications). For descriptions of the engineering principles of geophysical sensors it is unrivaled.

*Kearey and Brooks, Introduction to Geophysical Exploration, Blackwells.* (Suitable for students specializing in Mineral Exploration. A less advanced book, but contains well written introductory material to most methods).

*P.V. Sharma, Environmental and Engineering Geophysics. Cambridge University Press.* (Suitable for students specializing in Geo-environmental or Geotechnical Engineering. A new, very well written book, at the intermediate level. Examples are specific to environmental and engineering geophysics. This book is so well written that I would encourage all interested students to own a copy).

In addition, there are a number of other good books that you will find useful from time-to-time:

*Grant, F.S. and West, G.F., 1965. Interpretation theory in applied geophysics. McGraw-Hill (out of print).*

*Parasnis, Principles of applied geophysics, Chapman and Hall.*

*Nettleton. Gravity and magnetics in Oil Prospecting. McGraw-Hill (out of print).*

*Garland, G.D., 1979. Introduction to Geophysics: Mantle, Core and Crust. Saunders (out of print).*

*Blakely, R. J., 1995. Potential Theory in Gravity and Magnetic Applications. Cambridge University Press.*

*Blaricom, R., 1992. Practical Geophysics II for the Exploration Geologist. Northwest Mining Association.*

*Reynolds, J.M., Introduction to Applied and Environmental Geophysics, John Wiley and Sons.*

*Hatton, L., Worthington, M.H. and Makin, J., 1986. Seismic data processing: theory and practice. Blackwell Scientific Publications.*

*Sheriff, R.E. and Geldart, L.P., 1995. Exploration seismology, second edition. Cambridge University Press.*

*Yilmaz, Ozdogan, 1987. Seismic data processing. Society of Exploration Geophysicists.*

(The titles above are in the library and on reserve)

## 1.7 The objectives of the course

This course aims to train you for your future careers as geoscientists and geological engineers. We think you need to be informed enough to make use of those geophysical techniques appropriate for your applications (engineering, earth science, mineral exploration or other). This does not mean we want to train you to become geophysicists (although some of you will). However, in whatever geoscience field you end up in, we want you to be able to speak knowledgeably to both your contractors and your managers, to be able to understand the geophysical surveys you commission (and understand how to know if there are problems) and to ultimately be *innovative* if there is a new problem that might lend itself to geophysical methods. In some cases, this may be the last applied geophysics course you take — if use this opportunity to consolidate your geophysical knowledge, your career will be enriched as a result. In other cases you will proceed to more advanced courses in which you will learn about geophysics at deeper level — this course gives you the basis on which to do this.

### 1.7.1 A comment on mathematics

I don't think that Applied geophysics can be effectively learned without some mathematics. Without mathematics the subject becomes superficial and unsatisfying and rarely goes beyond the level of "look for red areas on the images". None of the objectives listed above are possible without using a mathematical language to describe the physics of the measurements. The mathematics that are required are at the second year university level (calculus, ordinary differential equations, vector analysis and vector calculus). An appendix to this course covers some of the critical topics (scalars, vectors and the differential operators gradient, divergence and curl). Early tutorials in the course will be used to go over this material for the benefit of any student who is unsure of these topics.

If you are very unsure about mathematics, there is a good review textbook that will help you to get the required background. It is *Mathematics: A simple tool for geologists*, by David Waltham (Chapman and Hall, 2000).