Yukon University	School of Science
	GEOL 213 **Geophysics**
	Winter 2023 **3 Credits**
Course Outline	

INSTRUCTOR: Dr. Joel Cubley
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COURSE DATES: January 5 – April 14, 2023
COURSE TIMES: Tuesday/Thursday 10:30 am – 12:00 pm (lecture); Friday 1:00 pm – 4:00 pm (lab)

COURSE DESCRIPTION

This course provides an introduction to the principles of geophysics and context for how geophysical field techniques can be used to address geological and environmental problems. Students will develop competencies using basic geophysical equations to better understand geologic systems at a variety of scales, and predict the geophysical response to different rock types and structures. An emphasis will be placed on survey design and hands-on operation of geophysical equipment (electromagnetic, gravity, electrical, magnetic, ground penetrating radar (GPR) methods), as well as the subsequent processing and analysis of data. Lectures will showcase examples from local mineral exploration and mining projects as well as environmental applications.

COURSE REQUIREMENTS

Prerequisite(s): Successful completion of GEOL 105 (Physical Geology), PHYS 102 (Elementary Physics II) and MATH 101 (Single Variable Calculus II).

Corequisite(s): PHYS 102 may be a co-requisite *if* there has been prior completion of MATH 101.

EQUIVALENCY OR TRANSFERABILITY

Receiving institutions determine course transferability. Find further information at: https://www.yukonu.ca/admissions/transfer-credit

LEARNING OUTCOMES

Upon successful completion of the course, students will be able to:

- Describe basic geophysical aspects of the Earth (magnetic fields, gravitational fields, isostatic equilibrium, etc.), using northern examples when appropriate.

- Apply fundamental physics knowledge and basic geophysical equations to solve geoscience problems at a variety of scales and for various applications.

- Describe the physical properties fundamental to different geophysical survey methods, and the applicability of specific methods to different types of geologic problems.

- Predict the characteristic geophysical signatures of different rock types and structures for a range of ground geophysical methods including electromagnetic (EM), induced polarization (IP), DC resistivity, gravity and magnetic surveys.

- Explain how geophysical field data are manipulated or processed, perform basic data processing on raw datasets, and critically evaluate the effects of this processing.

- Design a geophysical survey and apply the appropriate methodology and practical procedures for a number of ground geophysical methods.

- Identify lithologic units, determine rock properties, and interpret the economic potential of geologic zones using a variety of borehole geophysical logs (e.g. electromagnetic, gamma ray, and density logging).

COURSE FORMAT

Weekly breakdown of instructional hours

This course consists of two 90-minute lectures and one three-hour lab period per week. It is expected that this course will require 3-5 hours/week of homework and additional reading. It is important to note that the time required will vary by individual.

Delivery format

All components are offered in a face-to-face format. Lab exercises will be conducted in classroom, computer lab, and field settings. Students are strongly encouraged to attend all lectures and lab exercises. Lab exercises can be completed only during lab periods and materials may not be available outside these hours. Off-campus field exercises must be completed during the allocated time with the instructor present. Students are expected to participate in fieldwork that may be physically demanding, requires travel over uneven ground, and may include data collection during inclement weather (sub-zero temperatures, rain, snow, etc.).

After an initial module focused on whole-Earth geophysics, this course is centered upon the theory, application and interpretation of different geophysical methods. For each method, students are expected to become confident with the underlying geophysical properties informing the recorded response, and the considerations governing survey design. In the field, safe operation of equipment and effective group dynamics are critical. After collection of data for each method, it is important that students understand the types of data processing and the impacts that processing has on the dataset. Ultimately, students should be able to take geophysical results and present them to a geological audience, clearly demonstrating how the survey results link to the examined (or mapped) geologic materials.

EVALUATION

Lab Reports and Analysis for Ground Geophysical Surveys (6)	40 %
Lecture Theory Assignments (3)	15 %
Midterm Lecture Exam	15 %
Final Lecture Exam	20 %
Final Lab Exam (Oral)	10 %
Total	100 %

Assignments

Lecture theory assignments consist of three problem sets assigned during the term – these will focus on the application of theory to real geoscience problems. Due to the targeted, local scope of the ground geophysical surveys conducted in lab, these problems and datasets will address larger regional and whole-Earth questions. Lecture assignments are due at the start of lecture on the date assigned by the instructor.

Each laboratory module will focus on a single geophysical method and take approximately two weeks. The first week of each module will involve survey design and execution, the second week is focused on data reduction, analysis, and interpretation. Laboratory reports are due one week after the data analysis session for each method. Reports are due at the start of the following lab class unless otherwise indicated by the lab instructor.

Late assignments will be graded based on the following scheme: a deduction of 10% per day up until a total deduction of 50% is reached, following that, assignments must be submitted prior to the date that the instructor hands back the graded assignment (set by the instructor), unless otherwise indicated by the instructor.

Exams

There will be three exams in this course: a midterm lecture exam, a final lecture exam, and a final lab exam (oral). Students must pass the lecture final exam to achieve an overall passing grade. The two written lecture exams are closed-book examinations. The midterm is a 1.5-hour exam offered during regular class time; the final is a 3-hour exam scheduled during the final exam period.

The oral exam is a 20-30 minute discussion between the student and a group of Earth Sciences faculty members. In a course that has a very high group work component, the aim of this discussion is to better understand the extent of individual learning and contributions of each student. A panel will include the course instructor as well as other Earth Sciences faculty members (a minimum of two).

Missed exams will be assigned a grade of 0% unless re-scheduling for a valid reason is approved and determined **in advance** of scheduled exam date. If there are known conflicts with exam scheduling, please see the instructor as soon as possible to discuss an alternative examination date.

COURSE WITHDRAWAL INFORMATION

Refer to the YukonU website for important dates.

TEXTBOOKS & LEARNING MATERIALS

Reynolds, J.M. 2011. An Introduction to Applied and Environmental Geophysics (2nd ed.). Wiley. 710 p.
ISBN: 978-0-471-48535-3

Digital versions (e.g. Kindle) are acceptable.

ACADEMIC INTEGRITY

Students are expected to contribute toward a positive and supportive environment and are required to conduct themselves in a responsible manner. Academic misconduct includes all forms of academic dishonesty such as cheating, plagiarism, fabrication, fraud, deceit, using the work of others without their permission, aiding other students in committing academic offences, misrepresenting academic assignments prepared by others as one's own, or any other forms of academic dishonesty including falsification of any information on any Yukon University document.

Please refer to Academic Regulations & Procedures for further details about academic standing and student rights and responsibilities.

ACCESSIBILITY AND ACADEMIC ACCOMMODATION

Yukon University is committed to providing a positive, supportive, and barrier-free academic environment for all its students. Students experiencing barriers to full participation due to a visible or hidden disability (including hearing, vision, mobility, learning disability, mental health, chronic or temporary medical condition), should contact Accessibility Services for resources or to arrange academic accommodations: access@yukonu.ca.

TOPIC OUTLINE

Module	Topic
1	**Geophysics introduction and whole-Earth geophysics**: Review of the Big Bang and the evolution of planets, gravity and geodesy, angular momentum, Earth's differentiation, Earth's heat and geothermal gradient, radioactive decay, review of basic Earth structure; geomagnetism
2	**Introduction to geophysical field techniques**: application of different geophysical methods, inverse and forward modelling, data filtering and reduction
3	**Seismic surveying:** elastic properties of solid material **(**stress and strain, bulk modulus, Young's modulus, Poisson's ratio, etc.), seismic wave types and propagation characteristics, wave propagation losses, introduction to reflection and refraction (wave behavior at boundaries)
4	**Seismic reflection and refraction techniques**: applications, data collection and processing, critical refraction, interpretation of seismic images to interpret crustal structure and thickness
5	**Earthquake seismology:** earthquake mechanisms and relationship to fault types and tectonic boundaries, location methods, interpretation of seismograms and their reflection of internal Earth structure, scales for intensity and magnitude of earthquakes
6	**Gravitational methods**: theory and applications, geoid and reference ellipsoid, isostatic equilibrium and isostasy, data correction and reduction
7	**Radiometric and GPR methods**: theory and applications, radioactive decay, electromagnetic spectrum, concept of the dielectric constant, reflection profiling and velocity soundings, and environmental considerations
8	**Magnetic methods**: theory and applications, magnetic moment and magnetic domains, Curie temperature and remanence, magnetic susceptibility, diurnal variations
9	**Electrical methods**: theory and applications, natural and induced currents, DC resistivity and induced polarization (IP) field techniques, common arrays, electrode and membrane polarization
10	**Electromagnetic methods:** theory and applications, principles of electromagnetic induction, eddy currents, time domain vs. frequency domain systems; skin depth, tilt-angle methods, effect of vertical and horizontal transmitter coils, VLF and AFMAG systems
11	**Borehole geophysics**: theory and applications, instrumentation, log literacy and log types, common borehole geophysical methods; spontaneous potential (SP)