Syllabus: Fall 2019

University of Wyoming Geol 3005

Principles of Geophysics: 4 credits

Time and Place:
Mondays, Wednesdays, Fridays: 11:00am-11:50am (50 min. lecture)
Room 216
Thursdays: 9:00-10:50am or 11:0-11:50am or 12:10-2pm.
(1hr 50min lab)
Room: ESB 1004

Instructor:	Dr. Mike Cheadle	TA: Daniel Ciraula
Office:	221	Office: ESB 2002
Email:	cheadle@uwyo.edu	dciraula@uwyo.edu
Office Hours:	Mon. Weds: 12:00-1:30	Tues 1:30pm-3:00pm
Phone:	721-5082	and Weds 3:30pm-5:00pm

Synopsis:

The goal of this course is to introduce you to the properties and processes of the physical Earth. Topics to be covered include structure of the Earth, seismology, gravity, and magnetism. We will take both a lecture and hands on approach, including some fieldwork using geophysical instruments, lab work, homeworks etc. as a means to convey geophysical methods.

Course Prerequisites**:** Junior or higher standing; Physics 1110/1210

Course Aims:
We will cover both Solid Earth Geophysics and Exploration Geophysics. The solid Earth Geophysics will cover the **structure of the Earth, and Plate Tectonics**. The following exploration methods will be covered: **Gravity, Magnetics, Seismic Refraction, Seismic Reflection.** In every sub-topic I will try to teach you the physical principles, the methodology, how we interpret the data and how each method is used for different applications (I will try to make it fun & relevant! And I will also try to make the material relevant to the geology of Wyoming. For example, we will read geophysical papers about the crustal structure of Wyoming.). Knowledge of algebra & trigonometry will be required. In all cases we will try to use a minimum of mathematical complexity, but we will be using math.

Student learning outcomes:

Upon completion of this course, you will be able to:

1. Communicate geophysical concepts with acceptable precision and accuracy;
2. Describe the Earth processes related to several large-scale geophysical phenomena;
3. Describe the core field practices associated with geophysical measurements

4. Explain fundamental concepts underlying common exploration geophysics methods;
5. Work through common geophysical problems using computer-based mathematical tools;

Class Format:

The class will consist of three 50min lectures per week **and one** 1 hour 50 minute lab. The best way to study for this course is to **attend the lectures** and **solve the problems**! Each lab or homework will be worth about 5% of your final mark. You will be able to discard the homework or lab. with the lowest mark. All problem sheets and labs and will be due one week after they have been set (late papers will not be accepted, without an excellent reason) and will be returned to you one week later.

Final Project: Around mid-term, I will expect you to get into pairs and choose one paper from a list of papers I will supply. The papers are chosen to be interesting case studies using geophysical techniques. They range from academic to applied, and from archeology to paleontology. Each pair of students will give a 10 minute oral presentation in the final week as though they were the geophysicists who did the survey. You will explain the problem, the methods used and the results achieved. Each student will also independently provide a 1 page extended abstract on the case study.

Grading/Evaluation:

GEOL 3005 grading will be as follows:

- Lab exercises/Problem sheets 50%
- Mid-term exam 1 10%
- Mid-term exam 2 15%
- Final Project 10%
- Final exam 15%

I do not curve grades.

Required examinations:

9th October. Exam 1- 50 mins (all material until this date)
8th November, Exam 2- 50 mins All material from after Exam 1
16th December, Final Exam All material from after Exam 2- 10:15am-11:15am

Attendance and Absence policies:

Students are expected to attend every class unless you have an acceptable reason. Experience shows poor attendance will lead to a poor grade.

What Is Expected of You:

- Regular attendance and alert participation. This class will work best if you participate in the labs and do the problem sheets and ask questions!
- Relax and have some fun with the topics in this class. This is useful stuff! The goal is for you to gain a fundamental understanding of some of the most useful geophysics and to learn how to use that geophysics to explore the subsurface of the Earth.

What You Can Expect of Me:

- I will provide lab exercises, and supplementary lecture material (photocopies of key papers and summaries) and help stimulate discussions during class.
- I will be accessible and will always be happy to answer your questions during class, during office hours, and by appointment.
- I would very much like your feedback on how this new course is progressing. The University will perform a formal evaluation at the end of the semester.

If you have a physical, learning, or psychological disability and require accommodations, please let one of us know as soon as possible. You will need to register with, and provide documentation of your disability to, University Disability Support Services (UDSS) in SEO, room 330 Knight Hall, 766-6189, TTY: 766-3073."

A&S - Students and Teachers Working Together:

Classroom Behavior Policy:

At all times, treat your presence in the classroom and your enrollment in this course as you would a job. Act professionally, arrive on time, pay attention, complete your work in a timely and professional manner, and treat all deadlines seriously. You will be respectful towards you classmates and instructor. Spirited debate and disagreement are to be expected in any classroom and all views will be heard fully, but at all times we will behave civilly and with respect towards one another. Personal attacks, offensive language, name-calling, and dismissive gestures are not warranted in a learning atmosphere. As the instructors, we have the right to dismiss you from the classroom, study sessions, electronic forums, and other areas where disruptive behavior occurs.

Electronic devices such as mobile phones should be set to silent or turned off. Laptops are, allowed for note-taking purposes. No video or audio recording during class is allowed to protect the privacy of your fellow students.

Classroom Statement on Diversity:

The University of Wyoming values an educational environment that is diverse, equitable, and inclusive. The diversity that students and faculty bring to class, including age, country of origin, culture, disability, economic class, ethnicity, gender identity, immigration status, linguistic, political affiliation, race, religion, sexual orientation, veteran status, worldview, and other social and cultural diversity is valued, respected, and considered a resource for learning.

Disability Support:

The University of Wyoming is committed to providing equitable access to learning opportunities for all students. If you have a disability, including but not limited to physical, learning, sensory or psychological disabilities, and would like to request accommodations in this course due to your disability, please register with and provide documentation of your disability as soon as possible to Disability Support Services (DSS), Room 128 Knight Hall. You may also contact DSS at (307) 766-3073 or udss@uwyo.edu. It is in the student's best interest to request accommodations within

the first week of classes, understanding that accommodations are not retroactive. Visit the DSS website for more information at: www.uwyo.edu/udss"

Academic Dishonesty

Academic dishonesty will not be tolerated in this class. Cases of academic dishonesty will be treated in accordance with UW Regulation 2-114. The penalties for academic dishonesty can include, at my discretion, an "F" on an exam, an "F" on the class component exercise, and/or an "F" in the entire course. Academic dishonesty means anything that represents someone else's ideas as your own without attribution. It is intellectual theft – stealing - and includes (but is not limited to) unapproved assistance on examinations, plagiarism (use of any amount of another person's writings, blog posts, publications, and other materials without attributing that material to that person with citations), or fabrication of referenced information. Facilitation of another person's academic dishonesty is also considered academic dishonesty and will be treated identically.

In other words, no cheating! Ths is an important aspect of scientific ethics. In this class you will have to quote or otherwise use material from various other sources. To avoid 'academic dishonesty' in this context, you will have to be careful to clearly distinguish between ideas that you have obtained from other sources, and ideas that you have generated yourself. In the course of class discussions, this will be a challenge that will be part of your responsibility in passing the course. Please note l expect you to use outside sources, and that is fine as long as you do not say or even imply they are your own and not somebody else's ideas.

Duty to Report:

UW faculty are committed to supporting students and upholding the University's non-discrimination policy. Under Title IX, discrimination based upon sex and gender is prohibited. If you experience an incident of sex- or gender-based discrimination, we encourage you to report it. While you may talk to a faculty member, understand that as a "Responsible Employee" of the University, the faculty member MUST report information you share about the incident to the university's Title IX Coordinator (you may choose whether you or anyone involved is identified by name). If you would like to speak with someone who may be able to afford you privacy or confidentiality, there are people who can meet with you. Faculty can help direct you or you may find info about UW policy and resources at http://www.uwyo.edu/reportit

You do not have to go through the experience alone. Assistance and resources are available, and you are not required to make a formal complaint or participate in an investigation to access them.

Student Resources:

CAMPUS RESOURCES

DISABILITY SUPPORT SERVICES: udss@uwyo.edu, 766-3073, 128 Knight Hall, www.uwyo.edu/udss
COUNSELING CENTER: uccstaff@uwyo.edu, 766-2187, 766-8989 (After hours), 341 Knight Hall, www.uwyo.edu/ucc
ACADEMIC AFFAIRS: 766-4286, 312 Old Main, www.uwyo.edu/acadaffairs
DEAN OF STUDENTS OFFICE: dos@uwyo.edu, 766-3296, 128 Knight Hall, www.uwyo.edu/dos
UW POLICE DEPARTMENT: uwpd@uwyo.edu, 766-5179, 1426 E Flint St, www.uwyo.edu/uwpd
STUDENT CODE OF CONDUCT WEBSITE: www.uwyo.edu/dos/conduct

Course Texts

I will supply you with many handouts during the course of this class to supplement the class lectures. Consequently, you should only buy the course text if you want to. However, I do recommend the following texts as resource texts. I have not placed them on reserve in the Brinkerhoff Library for 24-hour loan, but will do so if that's best for the class as a whole.

Recommended Resource Texts: Looking Into the Earth, by A.E. Mussett and M.A. Khan, Cambridge University Press ISBN-13: 978-0521785747. It is available at the University bookstore and on amazon.com (including as a Kindle e-book). (Call number QE501 .M87 2000).

The Brinkerhoff Library has the 1st edition

Other Useful Texts: The Solid Earth 2nd Ed, C.M.R. Fowler, Cambridge, 2004. Cambridge University Press. ISBN: 978-0521893077 (Amazon, Kindle etc.) (call number QC806 .F625 1990)

The Coe Library has the 1st edition

Schedule

Week 1 (4 Sept).	**Introduction to Course:** and employment in Earth Sciences – **Earth vs Mars vs Venus**- Water, life & why Earth?. **No lab**
Week 2 (9 Sept)	**Structure of the Earth and Seismology -** Waves, stress & stain, physical properties **Lab: Earth Structure**
Week 3 (16 Sept)	**Structure of Earth**: reflection/refraction, structure of the Earth, key discoveries **Seismic refraction** intro, waves and rays, critical refraction, head waves and diving waves **Lab: Field trip. HMK**
Week 4 (23 Sept)	**Seismic Refraction:** Slope intercept method, multi-layer case, reduced travel time plots **Lab: Seismic Refraction-**
Week 5 (30 Sept)	**Seismic Refraction** The real world: complications- faults, lateral velocity variations, uneven interfaces, dipping interfaces **Lab: Seismic Refraction PC lab**
Week 6 (7 Oct)	**Seismic Refraction-** Computer modelling, amplitudes, global properties, what does seismics tell us about the nature and origin of the Earth's crust? **Mid Term 1 (9th October)** **Lab: Field Trip**
Week 7 (14 Oct)	**Seismic Reflection:** Intro & basic principles & theory- amplitudes **Lab: Seismic Refraction PC Lab**
Week 8 (21 Oct)	**Seismic Reflection:** NMO, CDP stacking- How to produce a seismic section **Lab Seismic Reflection- calculations**
Week 9 (28 Oct)	**Seismic Reflection:** Velocities & Migration **Lab: Seismic Reflection- migration**
Week 10 (4 Nov)	**Seismic Reflection:** Interpretation & Resolution + Sequence Stratigraphy. **Lab: Seismic Reflection-Interpretation** **(Mid Term 2 (8th November)**
Week 11 (11 Nov)	**Gravity**: Intro & elementary theory **No Lab- HMK?**

Week 12 (18 Nov) **Gravity:** Instruments, surveys, data reduction and interpretation (direct & indirect)

Gravity Lab PC

Week 13 (25 Nov) **Magnetics:** Intro & elementary theory, instruments.

Thanksgiving

Week 14 (2 Dec) **Magnetics:** Surveying and Interpretation

Gravity/Magnetics Lab

Week 15 (9 Dec) **Course projects**. You will be expected to present the exploration geophysics paper you have chosen to read. You will give a 10 minute oral presentation as though you were the geophysicist who carried out the experiment. (You will also produce a 1 page executive summary). What was your objective? What techniques did you use? What results did you get? Should we hire you for future contracts?

Finals Week (16 Dec) **Final exam (1 hour) on all material since last exam**

Substantive changes to syllabus:

All deadlines, requirements, and course structure is subject to change if deemed necessary by the instructor. Students will be notified in advance both verbally in class, and via email if any changes are needed. It is unlikely that there will be any substantive changes.

GEOL 3005: Principles of Geophysics: Case Studies

The last week of the Geophysics course is "course project week". For this week, you will need to choose a partner and form a pair and pick a paper from the list below. The list covers a wide range of topics, which I hope you will find interesting. The hope is that listening to 12 different talks (plus your talk) during the last week of classes, will give you a broad insight into the many different applications of geophysics.

You will be expected to present the exploration geophysics paper you have chosen to read in a PowerPoint type presentation. You will give a 12 minute oral presentation as though you were the geophysicists who carried out the experiment. (You will also produce a 1 page executive summary). What was your objective? What techniques did you use? What results did you get? Should we hire you for future contracts?

Your presentations will be peer evaluated and both members of the team will receive the same grade. The "executive summaries" should, however, be your individual work and will be graded separately. The presentation will be worth 5% and the executive summary 5% of your final grade.

Make your choice…..

1. Seismic Refraction

Assessing the integrity of a landfill site *

Carpenter, P.J., Calkin, S.F., and Kaufmann, R.S., 1991, Assessing a fractured landfill cover using electrical resistivity and seismic refraction techniques: Geophysics, **56**(11), 1896-1904.

Refraction studies of a Roman temple

Cadarelli, E., and Nardis, R., 2001, Seismic Refraction, isotropic anisotropic seismic tomography on an ancient monument (Antonio and Faustina temple AD141): Geophysical Prospecting, **49**, 228-240.

Crustal structure beneath Wyoming

Gorman, A.R., et al., 2002, Deep Probe: Imaging the roots of western N.America: Canadian Journal of Earth Science, **39**(3), 375-398.

3D seismic refraction traveltime tomography at a groundwater contamination site

Zelt, C.A., Azaria, A., & Levander, A. 2006 Imaging a palaeochannel beneath Hill Air Force Base. Geophysics Volume 71 No 5 P H67-78

Assessing the Critical Zone

K.M. Befus, A.F. Sheehan, M. Leopold, S.P. Anderson & R.S. Anderson, 2011; Seismic Constraints on Critical Zone Architecture, Boulder Creek Watershed, Front Range, Colorado; Vadose Zone J. 10:915.–927, doi:10.2136/vzj2010.0108

2. Seismic Reflection

Detecting gas in a laterally variable Formation.

Focht, G.W., and Baker, F.E., 1985, Geophysical case history of the Two Hills Colony gas field of Alberta: Geophysics, **50**(7), 1061-1076.

Diffraction Tomography to locate buried dinosaur bones *

Witten, A., Gillette, D.D., Sypniewski, J., and King, W.C., 1992, Geophysical diffraction tomography at a dinosaur site: Geophysics, **57**(1), 187-195. (Also see Seismosaurus: The Earth Shaker, by D. Gillette. Columbia University Press. Call Number QE862.S3 G56 1994.

Mapping Gas Hydrates

Lieven Naudts, Marc De Batist, Jens Greinert, and Yuriy Artemov, 2009. Geo- and hydro-acoustic manifestations of shallow gas and gas seeps in the Dnepr paleodelta, northwestern Black Sea *The Leading Edge, September 2009, v. 28, p. 1030-1040, doi:10.1190/1.3236372*

Geotechnical assessment of a shale diapir

Henriet, J.P., Vershuren, M., and Versteeg, W., 1992, Very high resolution 3D seismic reflection imaging of small-scale structural deformation: First Break, **10**(3), 81-88.

Surveying a proposed hazardous waste facility

Slaine, D.D., et al., 1990: Mapping Overburden stratigraphy at a proposed hazardous waste facility using shallow seismic reflection methods: In; Geotechnical and Environmental Geophysics. Volume II-Environmental and Groundwater, Tulsa(OK), Society of Exploration Geophysicists, 273-280.

Seismic Investigations in the Vicinity of the Great Sphinx of Giza, Egypt

Thomas L. Dobecki and Robert M. Stoch, 1992: Reflection & refraction surveys of the ground around the Sphinx, looking at weathering and for cavities: Geoarcheology: An International Journal, Vol 7., No.6, 527-544. And see http://www.smithsonianmag.com/history-archaeology/Uncovering-Secrets-of-the-Sphinx.html

Testing the confinement of waste injection wells

Zinni, E.V., 1995 Sub-surface fault detection using seismic data for hazardous-waste-injection well permitting: an example from St John the Baptist Parish, Louisiana, Geophysics vol 60, p 468-475

High-resolution seismic characterization in an urban area: Subway tunnel construction in Barcelona, Spain.

D. Martí, R. Carbonell, I. Flecha, I. Palomeras, J. Font-Capó, E. Vázquez-Suñé and A. Pérez-Estaún 2008. Traveltime seismic tomography used to aid subway tunnel drilling in Barcelona, Spain, provides a detailed characterization of the shallow subsurface, including a complex network of faults and dikes. Geophysics vol 73 no.2, pp B41-B50.

3. Passive Seismics

Nuclear explosion detection

Miao Zhang, Lianxing Wen; Seismological Evidence for a Low-Yield Nuclear Test on 12 May 2010 in North Korea. Seismological Research Letters ; 86 (1): 138–145. This one is a little different and includes material we have n't covered in class.

4. Gravity

Finding cavities in the great Pyramid

Lakshmanan, J. and Montlucon, J., 1987, Microgravity probes the Great Pyramid: Geophysics: The Leading Edge of Exploration, **6**(1), 10-17.

Locating Caves

Rybakov, M., Goldshmidt, V., Fleischer, L. and Rotstein, Y., 2001, Cave detection and 4D monitoring: A microgravity case history near the Dead Sea: The Leading Edge, **20**, 896-900.

Groundwater and Bedrock

Carmichael, R., and Henry, G., 1977, Gravity exploration for groundwater and bedrock topography in glaciated areas: Geophysics, vol. 42, no. 4, p. 850-859.

Monitoring CO_2 Sequestration

Håvard Alnes, Ola Eiken, and Torkjell Stenvold, 2008. Monitoring gas production CO_2 injection at the Sleipner field using time-lapse gravimetry *Geophysics, November-December 2008, v. 73, p. WA155-WA161, doi:10.1190/1.2991119*

Monitoring Volcanoes

Maurizio Battaglia, Joachim Gottsmann, Daniele Carbone, and José Fernández. 2008, 4D volcano gravimetry *Geophysics, November-December 2008, v. 73, p. WA3-WA18, doi:10.1190/1.2977792*

Time Lapse microgravity & Collapsing Houses

M.W. Branston and P. Styles, 2003. The application of Time-Lapse Microgravity for the Investigation and Monitoring of Subsidence at Northwich, Cheshire. *Quarterly Journal of Engineering Geology and Hydrogeology, August 2003, v. 36, p. 231-244, doi:10.1144/1470-9236/03-243*

Time-lapse survey monitoring artificial aquifer in Denver, CO

Kristofer Davis, Yaoguo Li, and Michael Batzle, 2008, "Time-lapse gravity monitoring: A systematic 4D approach with application to aquifer storage and recovery," *GEOPHYSICS 73: November-December 2008 p. WA61-WA69. Doi: 10.1190/1.2987376*

5. Magnetics

Mineral Exploration

Ketola, M., (1979) On the application of geophysics in the indirect exploration for copper sulphide ores in Finland. In Hood, P.J. (ed), Geophysics and Geochemistry in the search for Metallic Ores, Geological Survey of Canada, Economic Geology Report 31, 665-684.

Archeology: (must do both papers)

von der Osten-Woldenburg, H., et al., 2002, Magnetic mapping of a Bronze Age tumulus in France before and during excavation: The Leading Edge, vol.21, no.5, p. 465- 466.

Carderelli, E., et al., 2002, Integrated geophysical surveys to investigate the Scarsella vault of St. John's Baptistry in Florence: The Leading Edge, vol.21, no.5, p. 467-470.

Finding unexploded bombs

Les P. Beard, William E. Doll, T. Jeffrey Gamey, J. Scott Holladay, James L.C. Lee, Nathan W. Eklund, Jacob R. Sheehan, and Jeannemarie Norton, 2008. Comparison of Performance of Airborne Magnetic and Transient Electromagnetic Systems for Ordnance Detection and Mapping J ENVIRON ENG GEOPHYS, September 2008, v. 13, p. 291-305, doi:10.2113/JEEG13.3.291

Ocean floor survey over Mid-Atlantic Ridge

Tivey, Maurice A., et al. “A Near-Bottom Magnetic Survey of the Mid-Atlantic Ridge Axis at 26°N: Implications for the Tectonic Evolution of the TAG Segment.” Journal of Geophysical Research: Solid Earth, vol. 108, no. B5, 27 May 2003, pp. EMP 15–1-15–13., doi:10.1029/2002jb001967.

6. Multi-disciplinary

Chicxulub Impact Crater (Reflection and Gravity)

Hildebrand, A.R., et al., 1998, Mapping Chicxulub crater structure with gravity and seismic reflection data: In; Meteorites: Flux with Time and Impact Effects, Eds. M.M. Grady, R. Hutchinson, G.J.H. McCall and D.A. Rotherby, Geol. Soc. Spec. Publ., **140**, 153-173.

Determining the source of water for a national landmark (Gravity and Refraction)

Wolfe, P.J., and Richards, B.H., 1990, Geophysical Studies of Cedar Bog: In; Geotechnical and Environmental Geophysics. Volume II-Environmental and Groundwater, Tulsa(OK), Society of Exploration Geophysicists, 281-288.

Relating seismic damage to geological structure (Gravity and Refraction) Virginia & Karri

Alvarez, R., 1990, Structure of the Basin of Mexico City and its Relation to Destruction in the Earthquake of 1985: In; Geotechnical and Environmental Geophysics. Volume III-Geotechnical, Tulsa(OK), Society of Exploration Geophysicists, 263-280.

Exploring old waste sites (Refraction and magnetics)

Reynolds, J. M., 2002 The role of environmental geophysics in the investigation of an acid tar lagoon, Llwyneinion, North Wales, UK. First Break, vol 20, p 630-636.
For good quality pictures, you will need to get the paper copy from the library.

Examples of course materials for GEOL 3005