

# COURSE SYLLABUS

**GEO 5670/6670**

**Inverse Theory**

**Spring 2017**

**MWF 8:30–9:20 am rm 217a**

**Professor:** Tony Lowry (Department of Geology)  
• Geology Bldg Room 106 (Phone: 797-7096)  
• Email: Tony.Lowry@usu.edu  
• Office Hours: MWF 2:30-3:30pm (or by appt)  
• Website: <http://aconcagua.geol.usu.edu/~arlowry/Inverse/index.html>

## COURSE DESCRIPTION

Inverse theory is a set of methods used to extract useful inferences about the world from physical measurements: a toolbox that enables us to pin our quantitative observations to an optimally parameterized model. Historically, inversion has been most heavily used in the field of geophysics, but truth-be-told **any** geological, geochemical or other type of measurement that can be quantified and modeled can also be inverted for a “best” answer.

Chances are, if you’ve ever done some sort of modeling or other data analysis, you have performed at least some crude form of data inversion. A simple application of inverse theory is the fitting of data to a straight line. Tomographic imaging performed for a medical CAT scan is another, more sophisticated application. Often our measurements of the Earth are made far from the location of interest; typically they are also relatively few in number and noisy to boot. Consequently it is critical to understand not just what the “best” model is given some metric, but also the limitations of the data and the range of more-or-less equally possible solutions. Inverse theory enables us to characterize the certainty or uncertainty that we can ascribe to a particular model, the spatial or temporal resolution of our data, and the fundamental limits of what we can say from a particular dataset.

Not surprisingly, the tools we will discuss in this course are fundamentally mathematical. I make no apology for that, but note that we’ll be sticking to basic concepts of calculus, linear algebra and probability & statistics that should be familiar territory (and when they’re not, we’ll take it slow).

Ultimately, this course is meant to provide you (the student) with a set of tools and skills that will be helpful in both your current thesis research and your later career.

### **About the professor:**

I am a geophysicist (“Physics of the Earth”) who focuses on measuring and understanding how and why planets deform. On Earth, this relates directly to processes of fault slip, earthquakes and volcanoes, but also has implications for mass transfer in the atmosphere, hydrosphere and cryosphere.

### **Course Text**

(Required): **Geophysical Inverse Theory** (Menke).

(Recommended): **Geophysical Inverse Theory** (Parker).

## TENTATIVE SCHEDULE

Date	Topic
<b>9–13 Jan:</b>	Introduction/Motivation; Probability & Statistics
<b>18–20 Jan:</b>	Ordinary Least Squares; Model Parameter Error (Jan 16 is MLK Day; no class)
<b>23–27 Jan:</b>	Solution Appraisal; Weighted Least Squares
<b>30 J–3 Feb:</b>	SVD; the Generalized Inverse; Damped Least Squares
<b>6–10 Feb:</b>	Maximum Likelihood Method; Nonlinear Inversion
<b>13–17 Feb:</b>	Stabilizing Gauss-Newton Solutions; Deterministic Searches
<b>21–24 Feb:</b>	Monte Carlo and Simulated Annealing Methods (Feb 20 is President's Day; 21 <sup>st</sup> is Monday schedule)
<b>27 F–3 Mar:</b>	L1 norms and Inequality Constraints; Linear Programming
<b>6–10 Mar:</b>	Spring Break
<b>13–17 Mar:</b>	Inequality Constraints; Quadratic Programming
<b>20–24 Mar:</b>	Inequality Constraints for Nonlinear Problems
<b>27–31 Mar:</b>	Joint Data Inversion
<b>3–7 Apr:</b>	(Probabilistic) Likelihood Filtering and Joint Inversion
<b>10–14 Apr:</b>	Bayesian Inversion
<b>17–21 Apr:</b>	Simulation Assessment of Parameter Error
<b>24–28 Apr:</b>	Special Topics/Reading
<b>Final Course Project:</b> This will require both an oral presentation and a written report, both delivered on the final exam date ( <b>Friday, 5 May, 7:30-9:20 am</b> ).	

Web materials (incl. ppt's) and announcements will be available at  
<http://aconcagua.geol.usu.edu/~arlowry/Inverse/index.html>

<b>Grading:</b>	<b>5670</b>	<b>6670</b>
Exercises	~3	50% 25%
Take-Home Final Exam		50% 25%
(Grads) Semester Project		50%

### **Late Assignment Policy:**

All assignments are due at the date & time specified; no late assignments will be accepted. If you're not finished, just hand in what you have. Note that, because all assignments are to be submitted to me by email, I will not accept illness as an excuse for late assignments (unless the illness induces a coma). Paper or digital formats are acceptable; digital formats must be .pdf or .docx (MSWord).

### **Differences between the 5000 and 6000 level course:**

In addition to doing a semester project, as noted above, taking the course at the graduate level entails doing a few additional (more challenging) problems for the assignments and exams.

**Notice to veterans and students with disabilities:** Students with ADA-documented physical, sensory, emotional or medical impairments are eligible for reasonable accommodations. Veterans also are eligible for services. These are coordinated through the Disability Resource Center, Rm 101 of the University Inn, (435)797-2444, (435) 797-0740 TTY, or toll free at 1-800-259-2966. Please contact the DRC as early in the semester as possible. Alternate format materials (Braille, large print or digital) may be made available with advance notice.