**Syllabus and Course Description**
**Geophysical Geodesy Fall 2017**
**GPH 411/611**

**Course Location**: LME 415
**Course Time**: Tuesday & Thursday 3:00 - 4:15
**Units:** 3

**Instructor Name:** Bill Hammond
**Office Location:** SEM 315
**Phone Number:** 775-784-6436
**Email Address:** *whammond@unr.edu*
**Office Hours**: Thursday 11am - 12pm

**Course Description:**
This course develops the basic concepts and practice of geophysical geodesy, with an emphasis on the measurement and modeling of deformations of the solid Earth using precise space-based methods such as GPS and InSAR. Topics include the earthquake cycle, tectonic plate boundary deformation, volcanoes, subsidence, etc. The curriculum will emphasize the relationships between data and models, recent seismic events, and provide an overview of new national geodetic facilities such as the EarthScope Plate Boundary Observatory. The course is appropriate for graduate students and upper division undergraduates, and has in recent years been a catalyst for incorporating geodesy into Masters and Ph.D. theses.

**Course Prerequisites:** GPH 333 and PHS 301 (or permission from instructor)

**Required texts, course materials:**
No required text or materials

**Course Objectives and/or learning outcomes:**
Students will acquire knowledge of modern space geodetic technologies (e.g. GPS and InSAR), their precision, capabilities and limitations. They will develop skills in building quantitative computer models that explain geodetic data in terms of solid Earth processes.

**Description of Assignments:** (exams, quizzes, projects, papers)
Readings with group discussions
Problems sets
1 Mid-term
Project involving computer programming/data analysis
Graduate students do more sophisticated project and give an oral presentation.

**Grading Criteria:** (undergrad/grad 600 level/grad 700 level %)

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| Participation - Includes attendance, contribution to class discussions | (10%/10%/5%) |
| Problem sets - Graded according to completeness, neatness, correctness | (30%/20%/5%) |
| Mid-term - Graded | (20%/20%/5%) |
| Projects - Graded on completeness, neatness and quality | (20%/20%/40%) |
| Presentations - Graded on content, preparation, clarity, structure, diction | (20%/15%/40%) |
| Reading Summaries - 3 papers read thoroughly, 1-2 page written summary | (0%/15%/5%) |

Assignments handed in late will be accepted at reduced value towards grade.

*Additional Requirements for 611/700 level credit:*

Students who take this course at the graduate level will be required to do a more sophisticated numerical analysis or modeling project and present the outcome of this project orally to the class at the end of the term. Undergraduates are not required to write the paper summaries.

Project is comprised of Project/Presentation/Reading Summaries and together sum to 40% for undergrads, 50% for grad 600, 85% for grad 700 level.

Roll will be taken at class. Participation grade is partially based on attendance record.

**Academic Dishonesty Policy:**
Students are expected to adhere to the ethical code as described in the UNR Student Handbook. This code specifies that with enrollment, an individual commits to the principles embodied in the code. Academic dishonesty in any form is unacceptable. In the event of an academic dishonesty issue, the procedures for addressing the issue are outlined in the University's "Academic Dishonesty Procedures", which can be obtained from the Director of Student Judicial Affairs in the Jones Visitor Center.

**Students With Disabilities:**
Students with disabilities or who require special accommodations should notify the instructor at the beginning of the course so that suitable arrangements may be made.

**Statement on Audio and Video Recording:**
Surreptitious or covert video-taping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy. This class may be videotaped or audio recorded only with the written permission of the instructor. In order to accommodate students with disabilities, some students may be given permission to record class lectures and discussions. Therefore, students should understand that their comments during class may be recorded.

**Academic Success Services:**
Your student fees cover usage of the Math Center (784-4433 or www.unr.edu/mathcenter/), Tutoring Center (784-6801 or www.unr.edu/tutoring/), and University Writing Center (784-6030 or http://www.unr.edu/writing_center/). These centers support your classroom learning; it is your responsibility to take advantage of their services. Keep in mind that seeking help outside of class is the sign of a responsible and successful student.

**Course Calendar/Topics Outline:**

I. THEORETICAL BASICS & TOOLKITS

week 1. August 29, 31 (GEOFF)
- Introduction to the Class and the Geodetic Lexicon
- Class Goals and Logistics
- Pillars of geodesy - what we *will* and *won't* cover in this class
- Shape of the Earth
- Earth's gravity field and geoid
- Datums
- latitude, longitude
- What is height?
- Modern geodetic technologies
- How GPS works/Intro to GPS

*Problem set #1 - getting started with MATLAB* week 2. September 5,7 (GEOFF)

Reference Systems, Frames and Transformations
Reference frame basics (Earth Centered, Earth Fixed, CM, CE, CF, etc.)
The International Terrestrial Reference Frame vs.
North America Reference Frames
The Western US Velocity field, basic properties.
Helmert 7-parameter transformations: Rotation, Translation, Scale
Euler Rotations: A plate moving on a sphere
Coordinate Transformations: X,Y,Z to N,E,U
Uncertainty and Covariance
Models and Data
Solving for the slope of a line using linear inverse theory
MIDAS

*Problem set #2 - Solve for rates/slopes of lines from GPS time series*

week 3. September 12,14 (GEOFF)

Fundamentals of Plate Rotation and Deformation:
Velocity gradients
Strain and Strain Rate
Strain tensors, 2 and 3 dimensions
Rotation versus strain
Invariants
Estimating strain or strain rate
Continuum models: Strain Rate Maps
Plane strain vs. non-plane strain

*Problem set #3: Solve for Euler pole rotation parameters.*

week 4. September 19, 21 (GEOFF)

Fundamentals of Rheology, Stress, Elasticity, Viscosity
Shear and bulk moduli
Stress vs. Strain
Other rheologies, e.g. viscoelasticity
Power law rheology
Laboratory experiments
Simple analog models
World Stress Map

*Reading Summary 1 due (grads only).*

*Problem sets #4 - Solve for strain rates from velocity fields*

week 5. September 26,28 (BILL)

Interferometric Synthetic Aperture Radar (InSAR)
What is InSAR?
How does InSAR work?
Strengths, Weaknesses
Earthquakes (e.g. Wells, NV),
Subsidence (e.g. Las Vegas, LA Basin)
InSAR Time series analysis, SBAS
GPS and InSAR
Sierra Nevada uplift

*Problem set #5 - Project proposal due to Bill*

## II. CURRENT TOPICS, TECTONICS AND THE EARTHQUAKE CYCLE

week 6. October 3,5 (GEOFF)

Plate Motions
Plate tectonics, rigidity of plates
Description of motion, Euler poles
Comparison of geodetic data to geologic data: NUVEL-1

*Problem set #6: Exercises in Rheology - basic elements of stress/strain equations*

week 7. October 10,12 (BILL)

Plate Boundary Zones
Distributed continental deformation
Continuum vs. block representations
Stress in the lithosphere, boundary vs. gravitational stress
Basal tractions
Mantle structure, flow, influence
Vertical motions

*Problem set #7: Solving for slip rate on a fault*

week 8. October 17,19 (BILL)

The EarthScope Plate Boundary Observatory and the Nevada Geodetic Laboratory
Online tour of the Facilities
Instrumentation
Data products, Access
The Mobile Array of GPS for Nevada Transtension : MAGNET
Western US and Basin and Range tectonic deformation

*Problem set #8: Earthquake deformation forward models*

*Reading Summary 2 due (grads only)*

week 9. October 24,26 (BILL)

The Earthquake Cycle – Interseismic Deformation
Observations, Western U.S. perspective
Fault models
Savage and Burford, 1973. The arctan equation.
The San Andreas fault
Comparison between geologic and geodetic data.
Fault Creep

week 10. October 31, November 2 (BILL)

The Earthquake Cycle – Coseismic Deformation
What happens during an Earthquake?
The Earthquake as seen by Seismology vs. Geodesy
Using data to infer the properties of an earthquake model
Okada functions
Case studies:

- The 1906 San Francisco Earthquake

The February 2008 Wells NV earthquake
2008 Mogul Swarm
The coming big ones (Cascadia, Southern California, etc.)
Periodic, Time predictable and slip predictable models.
Episodic Tremor and Slip in Cascadia and elsewhere

week 11. November 7,9 (BILL)
The Earthquake Cycle - Post-seismic deformation
Observations and case studies
Transient vs. secular deformation
Afterslip
Viscoelastic postseismic relaxation
Models
Time series viewpoint

week 12. November 14,16 (BILL)
Volcanic and Magmatic Geodesy
Case studies from InSAR and GPS
Three Sisters, OR
Yellowstone
Long Valley, CA
Slide Mountain, NV
Afar Rift
Mogi deformation model
Sill Intrusion

*Reading Summary 2 due (grads only)*

week 13. November 21 (short week Thanksgiving) (GEOFF)
Vertical motions
Signals observed
Sierra Nevada Uplift
Drought-related uplift and elastic rebound
Annual/Seasonal motions
Glacial Isostatic Adjustment
Sea Level/Earth rotation
Fennoscandia and North America

week 14. November 28, 30 (GEOFF)
Subsidence
Hydrogeodesy
Poroelastic deformation
Structural controls on aquifer response

week 15. December 5,7 (BILL/GEOFF)
Available for problem set catchup/work on projects
Project presentations (depending on class size)
Cookies and Coffee. Need bakers.

week 16. December 12,14 Fall AGU no classes.

Finals week. (BILL/GEOFF)
Project Presentations
Cookies and Coffee. Need bakers.