Teaching Portfolio

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Contents

1 Teaching Statement

My main goal as a teacher is to evoke critical thinking in students. I believe critical thinking comes about only if lectures and class strategies are *interesting*, *well-thought*, and perhaps more importantly, *crafted for the right audience*. As a seismologist whose research mainly focuses on earthquake source mechanism and statistics as well as tsunamis, I strive to design courses and lectures that start off of the most relatable materials to students and then, using appropriate scientific tools, challenge them to think about some of the still open questions in the field, such as the important factors in earthquake cycle or efficiencies of tsunami models.

A main objective in my course design is always to create **interesting** lectures. The most fascinating aspect of Earth science to me has always been the variety of interesting issues – from the study of the Earth's interior to the governing dynamics of its surface processes – and the almost equally fun tools to address them. This, in principle, provides Earth science teachers with ample opportunity to create fun and at the same time challenging course content. Making a challenging content is easy enough, but will the students be motivated enough to face it? Therefore, this has always been a source of incessant thinking for me and is where I always have focused my efforts the most.

I spend a great deal of time preparing course content that would have students analyze ideas which require some level of creativity. In this respect, I always regard motivation as a fundamental aspect of teaching and therefore, I usually try to present the fun, real world applications while addressing the main ideas (e.g. Salaree et al, 2017). For instance, when teaching reflection/refraction in seismology, I throw in a number of interesting examples such as the idea of the dolphins and the SOFAR channel, tsunami propagation, etc. As Earth science also presents teachers with great opportunities to use multimedia sections in class, I usually make animations or plan to do short video interviews with colleagues discussing the fun aspects of their research to bridge the gaps between theory & method and application.

Obviously, it is important to prepare **well-thought** lectures and course plans. In my view, in devising an elaborate plan for classes, active learning is an invaluable resource as it will definitely result in more inclusive learning environments and will give students chances to get more involved in the learning process. While teachers have a presenter role in conveying syllabus topics and concepts, Earth science classrooms are very good examples of team learning. Teachers have excellent opportunities to take part in the learning process as peers to their students. This will facilitate achieving the course objectives with an input from everyone and is particularly interesting in Earth science classes where many of the topics are subject to fascinating debates. For instance, teachers can present simple ideas such as the Fermat's principle and then turn the class into a discussion room to derive the

Snells law through team work.

To accommodate active learning, my partially flipped classes usually consist of lectures, mini-seminars by the students, open short discussions, group discussions and not-graded quizzes. I also benefit from multimedia resources such as videos, sound clips (Stein *et al*, 2017) and online tools (e.g. `www.YouTube.com/AmirSalaree`). As a result, I try to plan the details and the pace of my classes and usually end up with detailed time plans.

Finally, perhaps the most important aspect of teaching is to **craft the material and plans for the right audience** and therefore it is crucial to regularly measure the effectiveness of teaching. As a result, I constantly try to sample the response of my class to my teaching and evaluation strategies. Although midterms and finals can, in principle, reflect the instructors performance, they are not the best measures to do so. Such one-off tools, are commonly biased due to several reasons (effects of students' stress on their performance, not comprehensively reflecting upon the course material, etc.), and therefore cannot be efficiently relied upon. Also, midterms and finals are post-mortem tools which may or may not be useful only for the next time a teacher will give a course.

For smaller classes, I usually assign a major portion of the course grade to individual projects by the students where they will have to discuss their work with teaching assistants on a weekly basis. This is, in principle, a more effective way to enhance student learning since it increases the students' engagement in the class and prevents students from being marginalized. Besides, in this fashion and through a well-thought and well-discussed project, students will end up with more appropriate workload. Throughout my teaching experience this has always resulted in more positive feedback from students as they will feel more in charge when they face more flexibility.

To find out if these goals are indeed achieved, I encourage the teaching team, either directly or through usual office-hour type conversations, to ask students about the effectiveness of the lectures and assignments. This is particularly useful since students are clever enough to understand if they are actually learning or simply bored/confused through lectures and/or pointlessly burdened with course work. Teaching assistants are then required to fill out standardized reports about the received feedback. Looking at the results of such conversations and through creating a personal memo, I tweak and improve the lecture structure and sometimes even the syllabus throughout the quarter as one must constantly keep improving.

Last, but not least, as an Earth science teacher, I believe that a good teaching strategy comes about by constantly improving the course content and evolving the necessary skills to convey them. In my view, change is always most effective through consistent steps. It is always better to improve teaching strategy throughout a given class than start to rethink lectures and the syllabus after a sometimes totally unsuccessful class. Students may also benefit tremendously from even smallest changes in the class. Such classes will become increasingly inclusive and intellectually involving to the students.

References

Salaree, A., S. Stein, N. Saloor, and R. P. Elling, 2017, December. Turn your smartphone into a geophysics lab, *Astronomy & Geophysics*, **58**(6), 6.35–6.36

Stein, S., R., Elling, Salaree, A., & M. E., Wysession, 2017. Unintentional Comedy – Errors in Movies and Educational Material – As a Teaching Tool, *AGU Fall Meeting*, New Orleans, USA

2 Teaching Experience

2.1 Teaching Publications

2018	Salaree, A., 2018. Using smartphone technology in geoscience education, *TEACHx, Pritzker School of Law, Northwestern University*
2017	Stein, S., Elling, R., Salaree, A., & Wysession, M. E., 2017. Unintentional comedy - errors in movies and educational material – as a teaching tool, *GSA Annual Meeting, Seattle, USA*
	Salaree, A., Stein, S., Saloor, N., & Elling, R., 2017. Turn your smartphone into a geophysics lab, *Astronomy & Geophysics*, **58**(6), 6.35–6.36
	Stein, S., Salaree, A., and Brooks, E., Teaching Assistantships: An opportunity, not a chore, *AGU Blogosphere*, Feb. 14, 2017
	Salaree, A., After Iran-Iraq earthquake, seismologists work to fill in fault map of the region, *The Conversation/Chicago Tribune*, Nov. 15, 2017

2.2 Teaching & Communication Awards

2018	2nd prize winner of the American Geophysical Union (AGU) Data Visualization and Storytelling Competition, *American Geophysical Union Fall Meeting, Washington DC*
2018	Graduate Service Award, *Department of Earth & Planetary Sciences, Northwestern University*
2017	Marion Sloss Teaching Excellence Award, *Department of Earth & Planetary Sciences, Northwestern University*

2.3 Teaching Certificates & Courses

2018	Faculty Advising: What You Need to Know and How to Do It Well, *Center for the Integration of Research, Teaching, & Learning (CIRTL), Northwestern University*
2016–2017	Teaching Certificate Program, *Searle Center for Excellence in Teaching, Northwestern University*
2011	Teaching Excellence Workshops, New TA Conference, *Searle Center for Excellence in Teaching, Northwestern University*

2.4 Teaching Assistantship

Earth 103 Geological Hazards (Emile Okal):	Fall 2013, Spring 2015
Earth 110 Exploration of the Solar System (Donna Jurdy):	Spring 2015
Earth 202 Earth's Interior (Suzan van der Lee):	Winter 2013
Earth 202 Earth's Interior (Seth Stein):	Fall 2014, Fall 2015, Winter 2017, Fall 2017

2.5 Lab Instructor

Physics 136-1 Physics Lab (Arthur Schmidt):	Fall 2018
Physics 136-3 Physics Lab (Arthur Schmidt):	Spring 2018

2.6 Guest Lecturer

Earth 103 Geological Hazards	Spring 2015
Earth 202 Earth's Interior	Fall 2014, Winter 2017, Fall 2017
Earth 320 Global Tectonics	Spring 2016
Earth 323 Seismology and Earth Structure	Spring 2018
Earth 324 Earthquakes and Tectonics	Fall 2018

2.7 Grading Assistantship

Earth 351 Forming a Habitable Planet (Seth Stein & Donna Jurdy):	Spring 2016

2.8 Professional Membership

2018–present National Association of Geoscience Teachers (**NAGT**)

3 Statement of Diversity

As an international student, I have had great opportunities while studying in a foreign country, culturally different from my own, Iran. Although, not always easy, I have endeavored to benefit from great mentors who, in many ways, taught me how to work as a team member in spite of the differences. I have constantly tried to use my less pleasant experiences as a minority student – marginalization, ethnic discrimination, etc – to build inclusive environments both as a researcher and as a teacher.

I firmly believe the diversity of the academic community has propelled the mindsets of scientists and transcended our ability to push the boundaries of knowledge through involving thinkers from diverse backgrounds. Of course, every once in a while, there would be obstacles, but one should – as I have – use the resulting momentum to take part in diverse conversations and collaborations while trying to approach people with different backgrounds through stimulating inclusive dialogues.

I believe that fruitful scientific collaborations happen only if the researchers feel they are taking part in a study as *peers* which is possible if they are mentored in an inclusive environment. Similarly, in many successful classes, students are encouraged to actively take part in the discussions as equals. In my view, Earth science classrooms can be great examples of *team learning*, as teachers have excellent opportunities in taking part in the learning process as peers to their students. In this way, everyone in the class will have an input while attaining the course objectives. To achieve an inclusive class, the students should also be encouraged to work in teams and avoid remaining quiet.

In order to facilitate this goal, I usually have small groups of students (selected from the last time) present or summarize certain topics from the previous lecture, at the beginning of every class. This not only is an excellent chance for the presenting individuals to draw upon their own backgrounds – in fact, I insist upon incorporating personal ideas and experiences – in making the topic their own, but also provides their classmates with a unique opportunity to get exposed to an idea they already know about, in new words – perhaps closer to their experiences. Another great benefit of this activity is preventing individuals – perhaps from culturally, intellectually or racially different backgrounds – from being marginalized.

Recently, I attended the Teaching Certificate Program at the Searle Center in Northwestern University, in order to learn more about these subtlties in academia and to develop the necessary skills in designing efficient strategies to create inclusive classrooms. While sharpening my teaching prowess through interactions with professors and fellow graduate students from diverse backgrounds as well as attending motivating workshops, I became determined to strive for a more inclusive academic community.

4 Potential Courses Qualified to Teach

Below, is a list of potential courses that I am qualified to teach along with a brief description for each course and suggested course syllabi. Please see the attached class plan and activities as well as syllabi.

- **Natural Hazards** (100- to 200- level):

  "The contents of this class can be tailored for introductory to intermediate levels."

  Natural Hazards is an undergraduate level course that serves as an introduction on the importance, mechanism and implications of natural hazards.

  In the 21st century, perhaps more than any time in history, we humans are exposed to natural hazards as we are expanding our habitats. While these phenomena cannot be prevented, with new advances in science and technology, we expect to be more alert in facing them. This class examines the challenges in facing and mitigating the hazards from earthquakes, tsunamis, landslides, hurricanes, tornadoes, and wildfires.

  With no prerequisite courses, we try to raise students' awareness in facing natural disasters. This is achieved through lectures, and extensive class work. Students examine our scientific & technological prowess in dealing with hazards through in-class activities designed for large undergraduate populations. These activities provide the class with a chance to revisit their knowledge & findings in a quantitative, hands-on fashion.

- **Introduction to Geophysics** (100- to 300- level):

  "The contents of this class can be tailored for introductory to intermediate levels."

  Introduction to Geophysics serve as an introductory course to geophysics in undergraduate level. We start from the most tangible characteristics of the our planet e.g., its shape and size, and try to explain such properties throughout the history of its formation. Physical concepts such as gravity, thermodynamics, acoustics, elasticity, as well as mineral physics are then used to analyze the class's findings in a quantitative, hands-on fashion.

  Through lectures, labs, assigned projects homeworks, and extensive class work, students are expected to get a good understanding of the main problems in geophysics and be able to develop the necessary skills to set up real life experiments to learn more about the Earth. We will explore interesting examples and applications of these concepts in the *real Earth.*

- **Plate Tectonics** (200- to 300- level):

  In the 1st century, our knowledge of the active global dynamics of the solid Earth is more than it has ever been before. We know that tectonic plates, the rigid chunks of outer shell of our planet are constantly moving and creating astounding features such as mountains, ridges, oceans, and islands on the surface. We know that the tectonic (Wilson) cycle is in charge of moderating Earth's environment by acting as a natural thermostat. Correct evaluation and modeling of the plates' kinematics will help us understand many of the critical aspects of hazards such as earthquakes and tsunamis.

  In this class, after a historical note, we will learn about the most important aspects of these features. We will work on the geometry, determination, and description of plate motions. In order to do so, paleomagnetism, marine magnetism, and hot spots will be discussed. Also, we will quantitatively discuss the formation, dynamics, evolution, and features of subduction zones and mid-oceanic ridges.

- **Seismology** (200- to 400- level):

  "The contents of this class can be tailored for introductory to advanced levels."

  We start by discussing the importance and implications of studying seismology. We then continue by looking at the elastic rebound theory and deformation of rocks. This will lead to the discussion of stress accumulation resulting in energy release in the form of waves.

  Generation, propagation, and types of waves are discussed in detail. Various approaches such as rays, elastostatics, elastodynamics, and normal modes of the Earth are used to address wave generation and propagation. Source mechanism, faulting, asperity models, earthquake slip distribution, seismic reflection & refraction and their coefficients, seismometry & its challenges, and basic concepts of seismo-acoustics are also discussed. Seismic interpretation of tsunamis and landslides can also be included in the discussions.

- **Hydrodynamics for Geoscientists** (200- to 300- level):

  "The contents of this class can be tailored for introductory to intermediate levels."

  An introductory to intermediate course on principles of fluid mechanics for undergraduate level. The concepts and ideas are designed to provide elementary background for *geoscience students. Lectures, labs, & class activities address the importance of using fluid mechanics to think of the issues in geosciences.*

Scales, material derivative, Darcy's law, Bernoulli's equation, and basic forms of conservation of mass and energy are addressed. Also, applications in geophysics, rock mechanics, chemistry, and biology are discussed.

- **Programming for Geoscientists** (200- to 300-):

  Introduction to algorithms and principles of programming for geoscientists. We will discuss important problems in many branches of Earth science such as geophysics, rock mechanics, geochemistry, and geobiology where simple coding can be extremely helpful.

  Simple introductions to the UNIX systems, shell scripting, and programming languages Python, MATLAB, R, and FORTRAN, numerical techniques, and discussion of basic libraries are included. We also discuss on data visualization techniques and issues. Simple scientific graphics & mapping softwares such as gnuplot, GMT, and ArcGIS, will be discussed.

- **Oceanography** (100-):

  The extent and importance of oceans on the Earth's surface are discussed. Ocean's origin in the framework of plate tectonics and Earth's formation, interaction of oceans with atmosphere, ocean circulation, energy transfer, waves, tides, ocean interaction with beaches, biological diversity, and environmental concerns in oceans are addressed.

- **Tsunamis** (300- to 400-):

  Serves as an intermediate to advanced geophysics course for graduate level. The concepts and ideas are designed to provide a brief mathematical background for geoscience students to understand the Physics of tsunamis.

  After providing a geological overview of tsunamis, we build up the governing equations from basic fluid mechanics. Concepts of stress & strain, Hooke's law, conservation of mass and momentum, and gravity waves are covered in the framework of fluids. This information is then used to address the generation, propagation and observation of tsunamis.

  Through lectures, labs, assigned projects, homeworks, and extensive class work, students are expected to get a good understanding of the main challenges in studying tsunamis and be able to develop the necessary skills to deal with tsunamis in more depth. We *will explore interesting examples and applications of the course topics as demonstrated hazard by tsunamis.*

While the course's main emphasis is to build a theoretical background, it also tries to provide students with a quantitative understanding of the phenomena through real examples and numerical analysis of tsunamis. The latter is achieved by extensive work on assigned term projects.

A background in geology is not required for this class as the necessary information will be provided in the form of assigned readings. Basic programming ability is desired but not required.

5 Sample Course Design

EARTH-2XX:
Introduction to Geophysics

5.1 Motivating Commitment

Statistically, only $\sim 20\%$ of the enrollments in this class are Earth majors/minors while $\gtrsim 70\%$ of students are usually from engineering disciplines and $\sim 10\%$ are non-STEM students who take the course either based on their personal interest or to satisfy degree requirements. This provides a wide range of backgrounds and interests, and in other words, *opportunities* for addressing various aspects of physical Earth science.

It is very important that all the students who take this class get involved in the discussions and contribute to the learning process, especially when there is such a diverse mixture of backgrounds and levels of prior knowledge on the subject. *Introduction to Geophysics* is designed to achieve this goal through motivating the students to learn.

Over the years, I have come to believe that motivation usually comes about through two things: applications and fun. Therefore, in this class, we will endeavor to present the fun, real world applications while addressing the main ideas. We also constantly try to slightly tailor certain parts of the course according to what students need and seem to be interested in. This results in is a critical balance on what *has to* be thought and what *is nice to*.

5.2 Syllabus

5.2.1 Reflection on the Syllabus

This course is designed to address the need to understand important aspects of our planet through a set of physical methods/skills. The timing and content are balanced for an 10 week (18 lectures, and 6 labs) quarter-based system, though it can be adjusted for semesters (15 weeks: 28 lectures and 8 labs) as well.

To effectively cover the course material, it is extremely important for students to work in an inclusive environment. This will facilitate the learning process as the students will draw upon their personal as well as class's reflections on the topics.

In this class, We will try to nurture critical thinking by letting the students participate in the development of topics. This is done through a partially flipped classroom, short open discussions, and not-graded quizzes. The quizzes are mostly designed to provide the instructor with a measure of how effective the instruction has been and are good metrics of students performance in the class. We will also demonstrate the importance of certain topics through the use of multimedia and/or fun resources.

5.2.2 Course Description

Introduction to Geophysics serve as an introductory course to geophysics in undergraduate level. We start from the most tangible characteristics of the our planet e.g., its shape and size, and try to explain such properties throughout the history of its formation. Physical concepts such as gravity, thermodynamics, acoustics, elasticity, as well as mineral physics are then used to analyze the class's findings in a quantitative, hands-on fashion.

Through lectures, labs, assigned projects homeworks, and extensive class work, students are expected to get a good understanding of the main problems in geophysics and be able to develop the necessary skills to set up real life experiments to learn more about the Earth. We will explore interesting examples and applications of these concepts in the real Earth.

5.2.3 Course Objectives

By taking this course, the students

1. will identify the main topics, i.e., gravity, heat, electromagnetics, plate tectonics and atmosphere in the physical study of the Earth.

2. can describe the reasons (scientific & social) behind the importance of Earth science. This is achieved through individual projects where students will get to create real-life experiments to address one of the topics covered in the course.
3. become familiar with various applications of the physics of the Earth's interior in different aspects of daily life.
4. gain the necessary skills to create real-world experiments about the course content (above).
5. can critically analyze various behaviors (e.g. gravitational, thermal, seismic) of our planet through physical concepts.
6. can critically analyze the impacts of these aspects on society.

5.2.4 Prerequisites

While no prior knowledge about Earth science is required, the students who take this course must have a fair background in Math (MATH-XXX & MATH-YYY) and Physics (PHYSICS-ZZZ).

5.2.5 Outline

Week	**Day**	**General Idea**	**Topics**	**Lab**
1	1	What/Where Is the Earth? Earth 101	Formation of the Solar System; Earth's Shape & Size; Intro to Plate Tectonics	Accuracy & Precision Lab
1	2	How Old Are We?	Radioactive Decay, Radiometric Dating	Accuracy & Precision Lab
2	3	Cavendish: The Man Who Weighed The Earth (Part I)	Gravity; Earth's Mass	Gravity Lab
2	4	Cavendish: The Man Who Weighed The Earth (Part II)	Kepler's Law, Moment of Inertia; Draft Earth's Structure	Gravity Lab
3	5	Let's Cram the Earth with Stuff!	Pressure, Isostasy	1st Group Project Meeting
3	6	How Does the Earth's Heat Engine Work?	Heat Sources in the Earth; Heat Transfer: Conduction	Heat Lab

4	7	Can We Drill Through Our Planet?	Heat Equation; Heat Transfer: Convection	Heat Lab
4	8	Tug of War between Pressure & Temperature	Minerals in the Earth; Mineral Structures; Rocks	-
5	9	Test	Midterm 1	Review Session
5	10	Seismic Waves: Warp of Energy	Elastic Moduli; P & S Waves; Snell's Law: Reflection & Refraction	Slinkies; Smartphone Array
6	11	Seismic Waves: Ultrasound of the Deep (Part I)	Reflection/Refraction Coefficients	Slinkies; Smartphone Array
6	12	Seismic Waves: Ultrasound of the Deep (Part II)	Travel-Time Curves; Locating Earthquakes; Waves vs Rays; Intro to Reflection Seismology	2nd Group Project Meeting
7	13	Seismic Waves: Ultrasound of the Deep (Part III)	Layers of the Earth; Seismic Evidence of the Earth's Core; Seismic Phases	-
7	14	Earthquakes: How? Where? Why?	Faults; Intro to Beachballs; Prelude to Plate Tectonics (I)	-
8	15	Electromagnetics: How Much Do We Know about the Oceans?	Earth's Magnetic Field; Oceans vs Continents; Paleomagnetism; Prelude to Plate Tectonics (II)	3rd Group Project Meeting
8	16	Plate Tectonics: The Breathing Engine of the Earth	Thermal History of the Earth; Wilson Cycle; Plate Kinematics	Plate Tectonics Lab
9	17	Plate Tectonics: Why Do We Care?	Earthquake Hazard; Environmental Concerns; Industrial Age; The Path Forward	Plate Tectonics Lab
9	18	Test	Midterm 2	Review Session
10	19	Last Group Project Meeting	Brush-Up; Presentation Practice	-
10	20	Final Project Presentations	-	-

5.2.6 Class Overview

We begin the class with two mini-lectures (~ 5 min each) by students reviewing material from the previous class. These lectures are extremely useful in revisiting ideas and concepts through having them rephrased by the students' peers.

Afterwards, there will be lecture and discussion through which student groups and the entire class work on concepts and equations (if any) together as a team. We will use multi-media resources and hands-on experiments in motivating and developing the ideas covered in throughout the course.

5.3 Sample Lesson Plan

5.3.1 Context for the Class

This class is designed to discuss the use of seismic waves in the study of the Earth. The shape of the seismic waves from earthquakes as well as their travel time in the earth can teach us a lot about the internal structure of our planet. Along with the other methods we have learned so far, i.e., gravity and electromagnetics, seismic waves provide us with an excellent insight about the Earths interior and help us understand why it behaves the way it does (InSight Mission).

After this class, students will be able to explain the reason why we use seismic waves to study the Earth. They can also use this information to design a simple experiment using their smartphones, to study the first top few meters of the campus parking lot. Students will turn in their justified sketches for a depth profile along with any recorded data they might have collected.

Students are strongly encouraged to skim through the following readings. While they are not required to work out the math, they should follow the logic behind the topics and ideas.

- Lay, T. and Wallace, T.C., 1995. Modern global seismology (Vol. 58). Academic press. Chapters 2 &3.
- Stein, S. and Wysession, M., 2009. An introduction to seismology, earthquakes, and earth structure. John Wiley & Sons, Chapters 3 &4.

Here are links to a number of videos created for this class:

- Sample smart phone experiment: `https://goo.gl/IEBca9`
- Record Gaps in Seismic Stations in the US: `https://goo.gl/I0a53Z`
- Earthquakes in the World: `https://goo.gl/rnAqF4`

5.3.2 Sample Class Plan

Here is a sample class plan for a seismology section:

1. The class will start with two students giving mini-lectures about (a) recording the seismic signals and (b) reflection and refraction of seismic signals at boundaries – both from the material presented in the previous lectures ($\sim$ 10 min). This will be followed by a very brief Q&A session afterward ($\sim$ 2–3 min).

2. We will then open the lecture by a quick review of the shape of seismic waves and how/why they are formed ($\sim$ 10 min).

3. Then a two-way problem will be presented through the use of effective graphics and slides: one can either take the propagation of seismic waves (the medium) for granted and find the earthquake location, or fix the positions of source and receiver and look for a good medium that can explain observations, or arrival times. A good example to explain the concept is how Google Maps directions work ($\sim$ 10 min).

4. The instructor will then formulate the simple case of locating an earthquake by using the P and S waves ($\sim$ 15 min). A good analogy is the idea of racing cars with different speeds.

5. The students will then be given a simple task of finding an earthquake's distance from their school; a seismic record from a nearby station will be used. Depending on the location of the institution, familiar earthquakes can be selected. For instance, for the East Coast, the 2011 Virginia earthquake, for the West Coast, the 2014 Napa earthquake, and for the Midwest, the 2015 Galesburg earthquake may be used. The students will divide into small groups and work on a reasonable answer using their knowledge about seismic velocities in the earth. The instructor (and teaching assistants if any) will walk around and participate in some of the group discussions and navigate the conversations ($\sim$ 10 min).

   - Students will turn in the results of their discussions in the form of individual written responses to a few short in-class questions. This ungraded quiz will not only give the instructor a useful metric of students' performance, but also will help the instruction team to improve the course content.

6. The lecture will then continue by now motivating multiple ways a seismic signal can get from a source to a receiver in a layered flat medium, by considering the idea of reflection and refraction at various boundaries ($\sim$ 10 min).

7. ***Deriving the travel-time equation/curve for the direct and reflected rays***: To do this, small, pre-designated groups will build simple equations following the handouts from the previous lecture (10 min) on the blackboard. Finally, in a group discus-

sion will complete the derivation (10 min) and conclude with the simple equations for the cases of direct & reflected P-waves.

- The group derivation helps the students to participate in the critical thinking and developing new ideas.
- The discussion will also provide them with a chance to contribute to a developing idea – which is the ultimate dream of science.
- Group discussions will prevent students from getting marginalized.

8. Finally, the class will watch a short video of an activity they will do in lab. The video will cover looking at the from compressional waves moving in a table and recorded by smartphones.
   - The videos will not only facilitate the learning process through the use of comprehensive visuals, they also provide the students with a broader perspective and gives them real-life examples of the applications of lecture topics. On the other hand, such visuals create a more fun atmosphere in the class and also could be depended upon as mental breathing times from the constant flow of information.

Note:

While the timing for the planned session seems tight, it is actually flexible. Depending on the *in situ* feedback from class, and students proficiency, the time for various planned segments can be changed and/or merged.

5.4 Feedback & Evaluation

5.4.1 Reflection

As there is no final exam in this class, Introduction to Geophysics is designed in a way that there are multiple opportunities for both the students and the teaching team to receive feedback – directly or indirectly – as I believe a good teacher MUST constantly sample reflections from among the students.

5.4.2 Assessment Plan

Students will receive feedback on their understanding of the course material through in-class questions (quizzes), homeworks, and labs. Although these assignments are eventually used for grading purposes, they are actually designed for the students to get a realistic idea on how they are doing and how much they are learning from the course.

Assessment	Rationale
In-Class Questions: Students answer simple questions which are passed out in the form of single page handouts while discussing them with peers and in the class.	They facilitate critical thinking about the lecture material + it motivates the students to attend all the lectures.
Mini-Lectures: Selected students (from last lecture) discuss and summarize the main points of the past lecture in the form of 10-minute mini-presentations.	Help the students to talk about/hear the lectures in different and more familiar words by their peers. Also, the random selection of *presenters* will cause the students to stay tuned.
Homeworks: Consist of problems dealing with what was addressed in the lectures and readings.	Help the students get familiar with more subtle aspects of the topics + provides them with a chance to practice.
Lab Reports: Combination of pre-labs and in-lab problems. These are self-containing packages consisting of descriptive, numerical and multimedia questions.	Provide students with unique chances to reinvent methods to address problems + gives them an opportunity to visualize topics.
TWO Mid-Term Exams	Combine students abilities to overview and think about the course material.
Individual Projects: Chosen jointly by the students and the teaching team. They are developed throughout the semester/quarter, with weekly progress reports and a final report to be submitted by the end of the semester/quarter	Combines the students' abilities, backgrounds, and interests with the skills they have acquired through the course to create comprehensible results as well as insightful report to help them identify and categorize their strengths and weaknesses.

5.4.2.1 Review Mini-Seminars

- **Format:** 5-minute seminars given at the beginning of each class and the Q & As afterward (2-3 minutes).

- **Planning:** At the end of every lecture, 1 or 2 students are randomly chosen to summarize certain topics from the lecture at the beginning of the next class. The student selection process is done hoping that every student will at least get a number of opportunities to do the assignment during the academic quarter/semester.
- **Philosophy & Goals:** I keep inclusive classrooms in high regards. I try to let everyone in the class participate in brushing up the lectures and forming the topics into more tangible material for their friends/classmates. Having the students rehash and summarize lecture material (plus any extras of their own) from previous lectures provides the class with a more comprehensive view of the material from the perspective of the students and prevents certain students from being marginalized. This assignment also provides the instructor with a good opportunity to receive feedback and have a good measure of the effectiveness of the past lecture. In an 80 minutes class, this assignment will take up to 18% of the class time. However, considering the benefits, it is definitely worth it.
- **Guidelines:**
  1. Summarize the assigned topics into 5-minute talks;
  2. Free format: presenters can use any means: blackboard/whiteboard, PowerPoint slides, other tools (handmade gadgets or cards, handouts, etc.);
  3. (optional) Use the lightning-talk format PowerPoint slides;
  4. Avoid using cluttered slides;
  5. Use of figures is strongly encouraged;
  6. Use of animations, movies and cartoons is encouraged;
  7. Figures are preferred rather than texts.
- **Grading:** Grading is done on a 0/1 basis. A satisfactory presentation will get a 1 and not giving the seminar will receive a 0. Partial credits may also be assigned. Giving bonus, fun material from students' own research will get them 0.5 points:
  - 0 pts — Not presenting.
  - 0 pts — Not understandable coverage of the topics AND inability in answering the questions raised after the seminar.
  - 0.5 pts — Not understandable coverage of the topics OR inability in answering the questions raised after the seminar.
  - 1 pts — Understandable coverage of the topics and answering the questions adequately.

  - +0.5 pts Extra material from the students' personal research additional input.

  The general idea, however, is to grade these mini-seminars mellowly. Any student who has put some effort and time into their presentation should receive full credit.

- **Sample Assessment:**

  The following students should summarize the ideas of *total internal reflection* and *the SOFAR channel* in the form of a mini-lecture. You can use the posted online material as well as many other online/textbook resources. Be brief and to the point. You should be able to take and answer questions from your classmates at the end of your talk.

  STUDENT A **STUDENT B**

5.4.2.2 Individual Projects

- **Timeline and Work:** In a 10-week quarter, projects will be assigned/picked and discussed during the 1st and 2nd week and the class will start working on their projects at around by the 3rd week. The students are required to set up weekly individual meetings with the TAs to discuss their progress and submit weekly reports. Final reports are due in week 8. The reports along with any results will receive comments and will be returned to the students for revisions which will be due by the end to the last week of class. Students will be evaluated based on the weekly and final reports they turn in to their TAs or the instructor.

- **Weekly Meetings:** Students will have to meet with the TAs on a weekly basis. They will have to present evidence of their progress and to discuss their work in some detail. This is not only a very good chance for the students to receive feedback on their work, but also an excellent opportunity for the course instructor and the TAs to measure their performance as the teaching team. In fact, following the meetings, the TAs are required to take notes of how well the ideas have been communicated to the students and how intellectually involved and interested the students are. They should try to ask the students how well they think the class is going or if they are confused about certain topics from the lectures. These notes, along any other ideas, suggestions, etc. the TAs might have will be discussed in the weekly meetings of the teaching team.

- **Instructor Evidence:** This assignment sets up an illuminative approach by providing the instructor with a chance to review the syllabus and timing budget of the class throughout the current quarter and decide if everything is actually going according to the plan. A major benefit of the proposed evaluation method is that the instructor will receive feedback from not just the students, but also from the teaching assistants. Also, students may be more willing to discuss their unknowns or misconceptions regarding the course material with the TAs rather than the professor due to various reasons.

- **Recent Evidence:** In a class I recently taught, I tried to have numerous one-on-one conversations with the students about the course material and asking for their input to modify the upcoming labs and lectures. The theme of most of the CTEC comments was something like He really wanted the students to learn the material or he was very helpful when we asked him questions.

  I believe such comments are due to the fact that because of the one-on-one discussions, students will get a better feeling of the intentions of the teaching team and will come to understand that the team actually cares!

5.4.3 Grades

Midterm (20%), Homeworks (20%), Labs (20%), Quizzes (10%), Mini-Lectures (10%), Individual Project (20%)

There is no final exam for this class.

The grading system is flexible as it is possible to get the lost points on homeworks and labs back during discussion sections with the TAs. To do this, students will have to modify their assignments by applying the comments and suggestions from their TA.

5.4.4 Sample Assessment

Labs are 2 hours long session in which students follow the instructions in their handouts. Lab packets are posted a week beforehand so that students will get a chance to thoroughly read through the instructions and answer the *pre-lab* questions.

For an overview of a typical portion of the lab section visit: `https://goo.gl/IEBca9`. The instructions and description of this particular lab session are included in the following 19 pages (pp. 8–24).

Students turn in the finished lab at the beginning of the next session, so they will have ample time to work on their results and ask for help if they need it. In-lab exercises and questions are worth 60% of the overall lab grade. While grading the in-lab material the following criteria are considered:

5.5 Research Question

5.5.1 Reflection

I have co-taught and TA'ed an introductory course in geophysics – although not exactly called that – to undergraduates as a distribution and/or degree requirement. The issue that we, as the teaching team, have always faced During this time, is that many of the students do not take the course seriously enough dismissing it as mere *distro* in which they can get by a B without missing much.

In principle, this is not surprising as non-Earth science students have their own curricular requirements and need to prioritize their time and energy according to what is most important in their future carrier – which is totally understandable. However, this somehow defeats the purpose of distro classes, as they are mainly designed to make the outsiders familiar with something outside their field and, if possible, spark some interest which has been missing simply due to not being exposed to the topic.

Nevertheless, according to my informal polls, many students do not take the class seriously because they dismiss it as *easy* and *not challenging* or something that you can get a B on without doing much. So I have decided to investigate if such students will actually tune in the class if they find it challenging enough.

Question: Will making more challenging course content make the students to tune in more in a distribution class?

Evidence: While a well-crafted midterm exam can, in principle, reveal the performance of students in the beefed-up class, more useful evidence can be acquired through routine checks. Throughout this class, the students are required to discuss their work on their individual projects with teaching assistants on a weekly basis. This is a more effective way to enhance student learning since it increases the students' engagement in the class and prevents them from being marginalized.

I encourage the teaching team, either directly or through usual office-hour type conversations, to ask students about the effectiveness of the lectures and assignments. This is particularly useful since students are clever enough to understand if they are actually learning or simply bored/confused through lectures and/or pointlessly burdened with course work. Teaching assistants are then required to fill out standardized reports about the received feedback. I will then use the results of such conversations and through creating a personal memo to evaluate the performance of the class.

In order to obtain a measure of the effectiveness of the plan, I need an initial reference point which I get through two questionnaires. I post the first questionnaire before the the class meets for the first time. In this document, students are required to answer questions about their *background* and *reason* for interest in the subject. The second questionnaire which anonymous is handed out during the first class, asks them about their *level* of interest and their *expectation(s)* from the class.

This data, along with a pair of final questionnaires – identical to the first two – which the students have fill out during the last class will be combined with the data from projects, homeworks, etc to decide if the original hypothesis was correct.

6 Sample Course Syllabi

6.1 Natural Hazards

Natural Hazards

Aug 2018

A. Salaree
Northwestern University

Course Description:

Natural Hazards is an undergraduate level course that serves as an introduction on the importance, mechanism and implications of natural hazards.

In the 21st century, perhaps more than any time in history, we humans are exposed to natural hazards as we are expanding our habitats. While these phenomena cannot be prevented, with new advances in science and technology, we expect to be more alert in facing them. This class examines the challenges in facing and mitigating the hazards from earthquakes, tsunamis, landslides, hurricanes, tornadoes, and wildfires.

With no prerequisite courses, we try to raise students' awareness in facing natural disasters. This is achieved through lectures, and extensive class work. Students examine our scientific & technological prowess in dealing with hazards through in-class activities designed for large undergraduate populations. These activities provide the class with a chance to revisit their knowledge & findings in a quantitative, hands-on fashion.

Course Objectives:

By taking this class, students:

- will recognize the importance of mitigating natural hazards;

- can identify the main geological & atmospheric hazards both in the US and in the world;
- can use their knowledge to raise awareness in their communities;
- will differentiate between the myths and facts regarding natural hazards;
- can determine the main sources of risk in the wake of natural hazard;
- will reflect upon their personal experience in their communities;
- create an introductory research presentable to the public in order to raise their awareness in facing natural hazards.

Prerequisite:

- **There are no prerequisite courses for this class:** (some basic knowledge of physics is encouraged).

Schedule:

Lectures:

- Mondays 10:30–11:20
- Wednesdays 10:30–11:20
- Fridays 10:30–11:20

Outline:

Week	Day	General Idea	Topics	Notes
1	1	Overview	importance of studying natural hazards; various forms of hazard; energy transfer; statistics	-
1	2	Earthquakes (I)	earthquakes; old ideas; faults (intro); plate tectonics	-

1	3	Earthquakes (II)	plate boundaries; geodetic measurements; plate motion	class activity: work with real data (smartphone experiment)
2	4	Earthquakes (III)	faults (types); faults of the world; destructive earthquakes	group project assignments
2	5	Earthquakes (IV)	waves; wave amplitude & period; recording waves; P & S waves	-
2	6	Earthquakes (V)	locating earthquakes	class activity: work with real data (IRIS)
3	7	Earthquakes (VI)	earthquake shaking; liquefaction; earthquake intensity; earthquake magnitude	-
3	8	Earthquakes (VII)	elastic rebound; recurrence time; earthquake prediction; earthquake hazard maps	class activity: work with real data (Google Earth)
3	9	Earthquakes (VIII)	earthquake mitigation; is warning possible	-
4	10	Test	Midterm 1	Review Session
4	11	Tsunamis (I)	what are tsunamis?; various tsunami sources; tsunamis: speed & size	-
4	12	Tsunamis (II)	tectonic vs. non-tectonic tsunamis	-
5	13	Tsunamis (III)	run-up & inundation; tsunami hazard: what tsunamis can do	-
5	14	Tsunamis (IV)	tsunami detection; mitigation & building; is warning possible?	-
5	15	Landslides (I)	earthquakes vs. landslides; types of landslide; what causes landslides; internal vs. external source	due: 1st group project progress report
6	16	Landslides (II)	karsts & sinkholes	-
6	17	Landslides (III)	landslide size & speed; landslide hazard; submarine landslides; mitigation; is warning possible?	-
6	18	Test	Midterm 2	Review Session

7	19	Volcanoes (I)	rocks & melts; types of volcano	-
7	20	Volcanoes (II)	volcanic hazards; volcanoes in the US & the world	-
7	21	Volcanoes (III)	volcanoes' size & speed; mitigation; is warning possible?	-
8	22	Hurricanes (I)	hurricanes & storms; hurricane size & speed; statistics; hurricanes, typhoons & cyclones	-
8	23	Hurricanes (II)	hurricanes formation; Coriolis effect; hurricanes' motion	-
8	24	Hurricanes (III)	anatomy of hurricanes; hurricanes in the US	-
9	25	Hurricanes (IV)	hurricanes hazard & mitigation; is warning possible?	-
9	26	Test	Midterm 3	Review Session
9	27	Tornadoes (I)	hurricanes vs tornadoes; statistics in the US; Fujita scale	-
10	28	Tornadoes (II)	formation of tornadoes; tornado season; detection of tornadoes; mitigation; is warning possible?	due: 2^{nd} group project progress report
10	29	Wildfires (I)	statistics; how does fire work?; component sources	-
10	30	Wildfires (II)	Fire hazard; convection; fires in the US; mitigation; is warning possible?	-
11	31	Natural Hazards & Policy	economic & other aspects of hazard policies; benefit/loss models; why is it so difficult to mitigate	-
11	32	Test	Midterm 4	Review Session
11	33	Final Group Project Presentations	-	-

Evaluation:

- **Class Questions:** 20%

- **Midterm 1:** 15% (12 Oct 2018)
- **Midterm 2:** 15% (31 Oct 2018)
- **Midterm 3:** 15% (19 Nov 2018)
- **Midterm 4:** 15% (30 Nov 2018)
- **Term Project:** 20% (7 Dec 2017 8:00 AM)

Project Description: TBD

Remarks:

- The proposed outline is flexible depending on the length of the academic semester/quarter and is subject to change.
- If you have any suggestions/concerns, please do not hesitate to contact me.
- **EMAIL:** `amir"AT"earth.northwestern.edu`
- **PHONE:** 847-491-8182
- **OFFICE:** Room #482, Technological Institute, 2145 Sheridan Rd, Evanston, IL 60208-3130
- **Webpage:** `sites.northwestern.edu/salaree`

Suggested Study Material:

- *Lecture notes and some of the important lecture slides will be regularly posted on the course website.*
- (Required Textbook) Abbott, P.L., 2008. Natural disasters (p. 512). *New York: McGraw-Hill*

6.2 Tsunamis

Tsunamis

Aug 2018

A. Salaree
Northwestern University

Course Description:

Tsunamis serves as an intermediate to advanced geophysics course for graduate level. The concepts and ideas are designed to provide a brief mathematical background for geoscience students to understand the Physics of tsunamis.

After providing a geological overview of tsunamis, we build up the governing equations from basic fluid mechanics. Concepts of stress & strain, Hooke's law, conservation of mass and momentum, and gravity waves are covered in the framework of fluids. This information is then used to address the generation, propagation and observation of tsunamis.

Through lectures, labs, assigned projects, homeworks, and extensive class work, students are expected to get a good understanding of the main challenges in studying tsunamis and be able to develop the necessary skills to deal with tsunamis in more depth. We will explore interesting examples and applications of the course topics as demonstrated hazard by tsunamis.

While the course's main emphasis is to build a theoretical background, it also tries to provide students with a quantitative understanding of the phenomena through real examples and numerical analysis of tsunamis. The latter is achieved by extensive work on assigned term projects.

A background in geology is not required for this class as the necessary information will be provided in the form of assigned readings. Some basic programming ability is desired but not required

Course Objectives:

By taking this class, students will:

- Identify the key concepts in dealing with tsunamis as a geophysical phenomenon;
- Use hydrodynamic tools to mathematically address the behavior of tsunamis;
- Carry out numerical analysis of the generation and propagation of tsunami waves;
- Determine the main observed features of tsunamis;
- Design numerical experiments to analyze tsunami features.

Prerequisite:

- **MATH-2XX (or equivalent):** Calculus
- **MATH-3XX (or equivalent):** Ordinary Differential Equations
- **MATH-3YY (or equivalent):** Partial Differential Equations
- **PHYSICS-1XX (or equivalent):** Classical Mechanics

Schedule:

Lectures:

- Tuesdays 12:30–14:20
- Thursdays 12:30–14:20

Labs:*

- Mondays 14:30–16:30
- Wednesdays 12:30–14:30

* *Students are required to register for <u>one</u> lab session from above.*

Outline:

Week	**Day**	**General Idea**	**Topics**	**Lab**
1	1	What Is a Tsunami? Tsunami 101	course overview; basic definitions; statistics; challenges	-
1	2	Background in Math: A Crash Course (I)	vectors & matrices; algebra; notations	-
2	3	Background in Math: A Crash Course (II)	vector calculus; Gauss & Stokes theorems	Term Project Assignments

2	4	Fluid Mechanics (I)	scales; material derivative; flow field	Term Project Assignments
3	5	Fluid Mechanics (II)	Newtonian flow; deformation & rate; strain	first group project meeting
3	6	Fluid Mechanics (III)	rotation; conservative forces; body vs. surface force; stress	first group project meeting
4	7	Fluid Mechanics (IV) – Governing Equations	pressure; conservation of mass & implications; Leibniz theorem	-
4	8	Fluid Mechanics (V) – Governing Equations	conservation of momentum; Navier-Stokes equation (I)	-
5	9	Fluid Mechanics (VI)	stress vs. strain; Hooke's law; Stokes' hypothesis; hydrostatic vs thermodynamic pressure	-
5	10	Fluid Mechanics (VII)	Navier-Stokes equation (II); incompressible flow; wave vs. diffusion equation	-
6	11	Fluid Mechanics (VIII)	boundary conditions in the Navier-Stokes equation; energy	second group project meeting
6	12	Fluid Mechanics (IX)	dimensions; non-dimensionalizing; Reynolds & Froude numbers; Bernoulli equation	second group project meeting
7	13	Fluid Mechanics (X)	gravity waves; boundary conditions; approximate solutions	-
7	14	Test	Midterm 1	Review Session
8	15	Let's Do Business: Tsunamis (I)	tsunamis as gravity waves; shallow water approximations;	-
8	16	Let's Do Business: Tsunamis (II)	overview: generation, propagation, observation	-
9	17	Tsunami Sources (I)	tectonic sources; sea floor deformation; static & dynamic representations; challenges	tsunami simulation lab (I): get to work with models; CPU time
9	18	Tsunami Sources (II)	frequency; dispersion; non-tectonic sources: landslides	tsunami simulation lab (I): get to work with models; CPU time