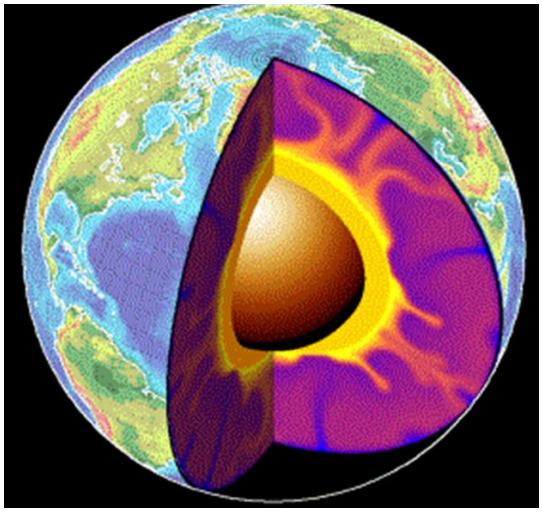
Department of Earth Sciences, Fall 2023

ERTH631: Solid, Fluid and Wave Mechanics



Instructor: Dr. Robert Dunn

POST 808, 956-3728
dunnr@hawaii.edu
office hours: by appointment

Lectures: **TTh 13:30-14:45 in POST 702**
Principle Text: Introduction to Continuum Mechanics, by Lai, Rubin, & Krempl
Reference Texts: Geodynamics, by Turcotte & Schubert
Elastic Wave Propagation and Generation in Seismology, by Pujol
Seismic Ray Theory, by Cerveny

The solid Earth deforms over a wide range of length and time scales, and in a variety of different ways in response to different forcing mechanisms. In this class, we will study continuum mechanics in geophysics, as applied to the deformation of Earth materials (elastic, viscoelastic, and plastic deformations) and seismic wave propagation (body waves, surface waves, anisotropy, and attenuation).

Catalog Description: ERTH631 Geophysics–Solid, Fluid, and Wave Mechanics (3) Continuum mechanics in geophysics, as applied to the deformation of Earth materials (elastic, viscous, viscoelastic, and plastic deformations) and seismic wave propagation (body waves, surface waves, anisotropy, and attenuation). Pre: (with a minimum grade of B-) for PHYS 170, PHYS 272, and MATH 307 or GG 312 (or equivalent).

Preliminary Schedule:

Week	Topic
1	Course Introduction Vector and Tensor Review
2	Stress in Solids The Stress Tensor
3	Rock Failure Moment Tensors for Earthquakes
4	Infinitesimal Strain Finite Strain and Geological Applications
5	Elasticity Elastic Deformation in the Earth
6	Ductile Rheology Navier-Stokes Equation
7	Viscous Flows (Couette & Poiseuille) Stokes Flow
8	The Stream Function Corner Flow / Non-Newtonian Rheology
9	Wave Mechanics – Equation of Motion Wave Mechanics – Boundary Conditions
10	Vector Wave Equation Vector Wave Equation
11	Wavefield Energy
12	Wavefields at Boundaries and Waveguides
13	Reflection and Transmission R&T Coefficients and Zoeppritz Equations
14	Eikonal Equation NO CLASS (Thanksgiving)
15	Ray Tracing Systems Surface Waves
16	Surface Wave Eigen-solutions Seismic Anisotropy / Seismic Attenuation

Grading

The relative weightings of homework assignments and class participation are as follows:

Homework	60%
Class Participation	40%

Other Reference Sources

Material Properties

Ranalli, G., *Rheology of the Earth*, Allen and Unwin, 1987.
Karato, S.-I., *Deformation of Earth Materials*, Cambridge Univ. Press, 2008.

Continuum Mechanics

Malvern, L. E., *Introduction to the Mechanics of a Continuous Medium*, Prentice-Hall, 1969.

Fluid Dynamics

Batchelor, G. K., *An Introduction to Fluid Dynamics*, Cambridge University Press, 1967.
Chandrasekhar, S. *Hydrodynamic and Hydromagnetic Stability*, Dover Publications, 1961.
Kundu, P., *Fluid Mechanics*, Academic Press, 1990.
Landau, L. D. and e. M. Lifshitz, 2nd ed, *Fluid Mechanics*, Pergamon, 1987.

Math and Mathematical Physics

Arfken, G., 3rd ed., Mathematical Methods for Physicists, Academic Press, 1985.
Marsden, J. D. and A. Tromba, 2nd ed., *Vector Calculus*, W. H. Freeman, 1981.
Press, W. H. S. A. Teukolsky, W. T. Vetterling, B. P. Flannery, *Numerical Recipes in Fortran: The art of scientific computing*, Cambridge University Press, 1992.
Schey, M., *Div, Grad, Curl, and all that: an informal text on vector calculus*, Norton, 1973.

Solid Earth Geophysics

Anderson, D. L., *New Theory of the Earth*, Cambridge University Press, 2007.
Davies, G., *Dynamic Earth: Plates, Plumes and Mantle Convection*, Cambridge University Press, 1999.
Fowler, C. M., *The Solid Earth: An Introduction to Global Geophysics*, 2nd ed., Cambridge Univ. Press, 2005.
Sleep, N. and K. Fujita, *Principles of Geophysics*, Blackwell Science, 1997.
Stacey, F.D. and P.M. Davis, *Physics of the Earth*, 4th ed., Brookfield Press, 2008.
Lowrie, W., *Fundamentals of Geophysics*, 2nd ed., Cambridge University Press, 2007.

Learning Objectives

The **Department of Earth Sciences** has established the following student learning objectives. All of these objectives are relevant targets for the curriculum of ERTH631.

1. Students can explain the relevance of geology and geophysics to human needs, including those appropriate to Hawaii, and be able to discuss issues related to geology and its impact on society and planet Earth.
2. Students can apply technical knowledge of relevant computer applications, laboratory methods, and field methods to solve real-world problems in geology and geophysics.
3. Students use the scientific method to define, critically analyze, and solve a problem in earth science.
4. Students can reconstruct, clearly and ethically, geological knowledge in both oral presentations and written reports.
5. Students can evaluate, interpret, and summarize the basic principles of geology and geophysics, including the fundamental tenets of the sub-disciplines, and their context in relationship to other core sciences, to explain complex phenomena in geology and geophysics.

Assignments: Assignments are due at the beginning of class one week after they are assigned (unless otherwise stated). Late assignments receive no points.

Format: Neatness, clarity of expression, and completeness are essential to obtain full credit on exams, reports, and homework. Please make sure to:
(1) Specify known and unknown information. Write out the equations, or derive new ones, that you will use to solve the problem. Explain your reasoning.
(2) Draw illustrative figures that describe the problem.
(3) Show clearly how you solved the problem.
(4) Check your answer – does your solution make physical sense? Check the units.

Cooperation: Collaboration between students is encouraged in order to discuss approaches to solving problems. However, work out the problems on your own and write out the solutions yourself. Anyone who shares their homework solutions openly is inviting others to copy it. Both will receive a zero on the assignment and both will be referred to UH's Office of Student Conduct for disciplinary action.

Mānoa Career Center: The Mānoa Career Center partners with faculty and employers to empower UH Mānoa students to engage in career life planning. Mānoa Career Center supports students and alumni in their career and personal development through awareness, exploration, experience, and reflection in university and non-university work-based learning opportunities. Some of the major programs and services include: career counseling, career planning sessions and workshops, graduate school planning, Co-operative Education and internships, part-time and full-time employment including Federal Work Study and campus recruitment, information sessions, and career fairs. For more information, please visit the Mānoa Career Center web site at: http://manoa.hawaii.edu/careercenter/.

Counseling & Student Development Center: Counseling and Student Development Center (CSDC) offers an array of services to meet counseling and testing needs among students, staff, and faculty of the UH Mānoa campus. Our multidisciplinary staff includes psychologists, psychiatrists, graduate-level therapists, and counselor trainees.

It is our mission to uphold excellence in quality of care that is respectful to the socio-cultural diversity of our clientele. We offer walk-in, individual, and group counseling, as well as career and psychological assessments.

When a client's needs could be best addressed by providers outside of the CSDC, we offer appropriate referrals in the community. We also provide outreach events to increase awareness on issues relevant to healthy campus lifestyle. For more information, please visit the Counseling & Student Development Center web site at: http://www.manoa.hawaii.edu/counseling/.

Basic Needs: Basic needs include food and housing, childcare, mental health, financial resources and transportation, among others. Student basic needs security is critical for ensuring strong academic performance, persistence and graduation and overall student well-being. If you or someone you know are experiencing basic needs insecurity, please see UH System Basic Needs at: https://www.hawaii.edu/student-basic-needs/

Disability Access: If you have a disability and related access needs the Department will make every effort to assist and support you. For confidential services students are encouraged to contact the Office for Students with Disabilities (known as "Kokua") located on the ground floor (Room 013) of the Queen Lili'uokalani Center for Student Services: KOKUA Program; 2600 Campus Road; Honolulu, Hawaii 96822. Voice: 956-7511; Email: kokua@hawaii.edu; URL: www.hawaii.edu/kokua

Title IX: The University of Hawai'i is committed to providing a learning, working and living environment that promotes personal integrity, civility, and mutual respect and is free of all forms of sex discrimination and gender-based violence, including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence, and stalking. If you or someone you know is experiencing any of these, the University has staff and resources on your campus to support and assist you. Staff can also direct you to resources that are in the community. Here are some of your options: As members of the University faculty, your instructors are required to immediately report any incident of potential sex discrimination or gender-based violence to the campus Title IX Coordinator. Although the Title IX Coordinator and your instructors cannot guarantee confidentiality, you will still have options about how your case will be handled. Our goal is to make sure you are aware of the range of options available to you and have access to the resources and support you need.
If you wish to remain ANONYMOUS, speak with someone CONFIDENTIALLY, or would like to receive information and support in a CONFIDENTIAL setting, use the confidential resources available here: http://www.manoa.hawaii.edu/titleix/resources.html#confidential

If you wish to directly REPORT an incident of sex discrimination or gender-based violence including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence or stalking as well as receive information and support, contact: Dee Uwono Title IX Coordinator (808) 956-2299 t9uhm@hawaii.edu.