Geodynamics II: The Fluid Earth

Course Description:
Fluids and fluid motion play major roles in numerous geologic processes on Earth's surface and interior. This course provides a quantitative introduction to the geologic fluids that shape our dynamic planet. Emphasis will be placed on mastering basic concepts in fluid mechanics and applying these concepts to a wide range of geologic problems. Goals include: (i) exploring important fluid systems of the Earth, such as atmosphere, rivers, groundwater, glaciers and magmas; (ii) providing an introduction to basic concepts in fluid mechanics, such as laminar versus turbulent flow, viscosity and convection; (iii) illustrating application of basic ideas, such as derivatives and integrals in mathematics to earth science problems; and (iv) developing the habit of thinking analytically and quantitatively. **Students will be tested on both key vocabulary and applications of the material covered in lecture to geologic problems. The latter will involve both clear, qualitative explanations of the mechanics involved as well as mathematical, quantitative analyses and calculations.** The course is designed primarily, but not exclusively, for majors. The texts, "Earth Surface Processes" by P.A. Allen and "Groundwater in Geologic Processes" by S.E.Ingebritsen, W.E. Sanford, & C.E. Neizil provide a quantitative treatment of much of the material related to surficial and shallow interior processes. For the part of the course which concentrates on processes in the deeper Earth, lecture notes and supplementary reading materials will be made available. Students with particular interests in groundwater (hydrogeology) are also referred to “Fundamentals of Groundwater” by F.W. Schwartz and H. Zhang.

Lab Description:
Labs will involve problem solving and physical experiments designed to illustrate many principles covered in lecture. Meet in Pillsbury 125B unless otherwise indicated by the TA.

Martin Saar (Prof)	Lesley Perg (Prof)	Stephen Schneider (TA)	Maria Davis (TA)
saar@umn.edu	lperg@umn.edu	schne564@umn.edu	davis923@umn.edu
Office: PillsH 21	Office: PillsH 30A	Office: PillsH 209F	Office: PillsH 125A
Phone: 625-7332	Phone: 624-3664	Phone: 626-1544	Phone: 624-9318
Office Hrs: MW 11-12	Office Hrs: MW 12-1PM	Office Hrs: TBA	Office Hrs: TBA

Web Site: http://www.geo.umn.edu/courses/3202/fall2006
Lecture: Mondays, Wednesdays: 1:25 PM - 2:15 PM (PillsH 110)
Labs: Thursdays: 09:05 AM – 11:00 AM (PillH 125B), TA: Maria Davis **or**
Thursdays: 12:20 PM – 2:15 PM (PillsH 125B), TA: Stephen Schneider **or**
Fridays: 9:05 AM – 11:00 AM (PillsH 125B), TA: Stephen Schneider

Course Grade:
Mid-Term Exam (Oct. 25): 25%; Final Exam (4:00PM-06:00PM, Dec. 20): 35%; Labs: 40%

Required Textbooks:
1) Earth Surface Processes, P.A. Allen, Blackwell Science Ltd., 404 pp., 1997. [This is also the textbook used in GEO 4701: Geomorphology.]
2) Groundwater in Geologic Processes, S.E.Ingebritsen & W.E. Sanford and C.E. Neizil, 2nd edition, Cambridge University Press, 562 pp., 2006. [This is also the supplemental book recommended for GEO 5701: General Hydrogeology].

Recommended Textbook (also on reserve in Walter Science Library for 2-hour check-out):
Fundamentals of Groundwater, F.W. Schwartz and H. Zhang, John Wiley & Sons Inc., 583 pp., 2003. (cost: ~$122 (new), ~$55 (used) from Amazon.com). [This is also the textbook used in GEO 5701: General Hydrogeology].

Teaching Goals:

To discover how some important fluid systems of the Earth work:

rivers	oceans	atmosphere	groundwater
mass flows	glaciers	magma/lava	mantle

To provide an introduction to basic concepts in fluid mechanics:

force balance	mass balance	viscosity	convection
mixing	laminar/turbulent flow		shear stresses and pressure

To show how some basic ideas in mathematics are applied to problems in the Earth sciences:

logarithms	exponentials	trig functions	derivatives
integrals	PDEs	gradients	dimensional analysis

To develop a habit of thinking analytically and quantitatively:

How fast can it go?	What forces are involved?
How much is transported?	How long does it take?
What are the key physical properties?	

Lab Schedule

Lab	Date	Topic
1	Sep. 7, 8	Applications of integration/differentiation to problems involving fluids
2	Sep. 14, 15	Calculation of shear stress, pressure, isostasy
3	Sep. 21, 22	Problems related to mass balance
4	Sep. 28, 29	Stoke's law experiment, Reynolds number
5	Oct. 5, 6	Convection experiment
6	Oct. 12, 13	Darcy tube lab
7	Oct. 19, 20	Visit to St. Anthony Falls Lab and review for mid-term exam
8	Oct. 26, 27	Fluid pressure and rock fracture
9	Nov. 2, 3	Glacial flow experiment model
10	Nov. 9, 10	Postglacial rebound experiment
11	Nov. 16, 17	Debris flow lab
--	Nov. 23, 24	no lab (Thanksgiving)
12	Nov. 30, Dec.1	Flume lab (St. Anthony Falls Lab)
13	Dec. 7, 8	Settling velocity and eolian transport lab
N/A	Dec. 14, 15	Review for final exam

Lecture Schedule

1	Sep 6	W	What is a fluid? Examples of geologic fluids	MS	Allen, Chap. 4
2	Sep 11	M	Forces on fluids + some flow equations	MS	Allen, Chap. 4
3	Sep 13	W	Forces on fluids + some flow equations	MS	Allen, Chap. 4
4	Sep 18	M	Analysis of a simple flow	MS	Allen, Chap. 4
5	Sep 20	W	Analysis of flow around a sphere	MS	Allen, Chap. 4
6	Sep. 25	M	Dimensional analysis and Reynolds number	MS	Allen, Chap. 4
7	Sep. 27	W	Real flows and turbulence	MS	Allen, Chap. 4
8	Oct. 2	M	Rheology of Earth materials (magma, rocks)	MS	Lecture Notes
9	Oct. 4	W	Convection in the Earth's mantle and core	MS	Lecture Notes
10	Oct. 9	M	Flow of magma and lava	MS	Lecture Notes
11	Oct. 11	W	Groundwater (hydrogeology) and Darcy's law	MS	I,S&N, Chap. 1
12	Oct. 16	M	Groundwater in geol. processes (heat)	MS	I,S&N, Chap. 3,7
13	Oct. 18	W	Groundwater in geol. processes (hydrocarbons)	MS	I,S&N, Chap. 6
14	Oct. 23	M	Groundwater in geol. processes (earthquakes)	MS	I,S&N, Chap. 8
15	Oct. 25	W	**MID TERM EXAM** (covers lectures 1-13)		
16	Oct. 30	M	Surficial Fluids	LP	Allen, Chap. 4
17	Nov. 1	W	Glacial flow I – ice flux	LP	Allen, Chap. 11
18	Nov. 6	M	Glacial flow II – rheology	LP	Allen, Chap. 11
19	Nov. 8	W	Isostasy revisited and post-glacial rebound	LP	Allen, Chaps. 1-2
20	Nov. 13	M	Glacial erosion, transport, and deposition	LP	Allen, Chap. 11
21	Nov. 15	W	Debris flow – rheology and deposition	LP	Allen, Chap. 6.4
22	Nov. 20	M	Flow in rivers	LP	Allen, Chap. 5
23	Nov. 22	W	Sediment entrainment and transport	LP	Allen, Chap. 5
24	Nov. 27	M	Bed forms – ripples and dunes	LP	Allen, Chap. 5
25	Nov. 29	W	River channels and networks	LP	Allen, Chap. 5
26	Dec. 4	M	Wind	LP	Allen, Chap. 10
27	Dec. 6	W	Eolian transport I	LP	Allen, Chap. 10
28	Dec. 11	M	Eolian transport II	LP	Allen, Chap. 10
29	Dec. 13	W	Self-organization	LP	Lecture Notes
	Dec. 20	W	**FINAL EXAM** **4:00-6:00 PM**, Wednesday, Dec. 20 in **Rapson Hall 31**. The final exam is comprehensive but with emphasis on lectures 14-29.		