GEOS 28600
Final exam
Winter 2020
Due at 8a (start of canonical hours) on Tuesday 17.
You can turn in the exam by email to kite@uchicago.edu (preferred)
or to my mailbox if you have your own key/card access to the Hinds building.

Parameters (all are important):
- Answers must be typeset. Sketches etc are permitted but must be incorporated into a single typeset answer (Word or pdf format if emailed).
- No collaboration (e.g., discussion of the questions) is permitted.
- The exam is open book but with strict implementation of the Student Manual academic policies on academic honesty in citation (https://studentmanual.uchicago.edu/). For specific examples of what the Student Manual is referring to, I cannot see a better UChicago-specific resource than Examples A and B at https://internationalaffairs.uchicago.edu/page/honest-work-and-academic-integrity-plagiarism . Another example is, if two sentences in a row draw on the same source, there must be a citation for each sentence. The purpose of highlighting these rules, which apply to all of the work that everyone does at UChicago (faculty included), is to encourage you to demonstrate your own understanding in your answers to the questions on the final.
- Iterated answers are acceptable, up to the deadline.
- Late rules: For fairness to all students, the reduction in maximum score will be 10% for every 10 minutes late turn-in.
- Points are equal for each question number.

Question 1. Consider a planet very similar to the Earth, with a mantle density of 3.3 g/cm^3, a continental crust density of 2.7 g/cm^3, a very thin oceanic crust. The water depth at locations where there is ocean is 1 km, and the height of the land above sea level is the same at all dry-land locations.

a) The continental crust is 35 km thick everywhere. In isostatic equilibrium, what is the average height of the land above sea level?
b) Now consider a more dense continental crust (same thickness). What is the maximum density of continental crust before the planet turns into a Waterworld (all land gets flooded)?

Question 2. In our discussion of mountains, valleys, isostasy, and flexure, we assumed that the spacing between ridges and valleys was small compared to the flexural wavelength of the lithosphere. How would the topography of a mountain range differ if that were not true? Explain your answer.

Question 3. How would age vary with closure temperature (for a hypothetical set of radiogenic chronometers that span a very wide range of closure temperatures, from 10°C to 500°C) if the erosion rate in a mountain belt was steady before 3 Myr ago, but increased by a factor of two 3 Myr ago to a new (higher) steady rate? How would it vary if the erosion rate had been steady throughout? Assume samples are acquired at the surface. Explain your answer.

Question 4. a) Why is the critical Shields stress for initiation of sediment transport approximately constant with grain size (for particles of gravel size and above?)
b) In class, we considered only fully submerged sediment clasts. Would your answer change if we consider initiation of motion as a function of grain size for clasts in a stream that does not fully submerge the smallest clast? Why or why not?

Question 5. According to Yoo et al. (Geology, 2005, v.33, p.917-920), "a gopher annually expends 9 kJ of energy, or 1% of reported burrowing energy expenditure, in generating sediment transport." At this rate, about how long would it take a colony of 100 pocket gophers to fill in Meteor Crater in Arizona (1.2 km diameter, 0.17 km deep)? A gopher is about 15 cm long. State any extra assumptions you make in answering this question.

Question 6. Rivers. State and explain three distinct hypotheses for controls on river long-profile concavity.

If m = 0.5 and n = 1, what are the dimensions (units) of erodibility K in the below equation?

$$\frac{\partial z}{\partial t} = U(x,t) - K(x,t)A(x,t)^m \left|\frac{\partial z}{\partial x}\right|^n$$

For topographic steady state, with constant and uniform uplift U, constant and uniform erodibility K, and A = (constant)*x (i.e., a rectangular catchment), solve the above equation for z = z(x) given the boundary condition z = 0 at x = 0.