Equation dictionary project
Spring, 2007

Description: When equations are presented in class or in the context of textbook reading, students first evaluate whether the equation is appropriate for use in the dictionary (is it useful in many situations or specific to one problem? Is it a "final" version of an equation, or can it be simplified? Is it likely to be used in solving geohysical problems?) Once an equation is selected for the dictionary, students add a "definition" that includes (a) a short description of each variable and relevant constants, including appropriate units, (b) a written description of the process or relationships presented within the equation, and (c) any additional notes that help them understand the equation. The dictionary may be used on homework and exams, which encourages students to describe the equations in a manner that is meaningful to them. Thus, rather than simply write down the equation for seismic moment, a student might add "Seismic moment is a function of the size of the fault as well as the rigidity of the rock. The larger the fault or the displacement, the larger the earthquake". This activity allows students to evaluate their understanding of equations and the underlying physical processes.

Goals: To increase student confidence in their quantitative abilities and improve their understanding of the relationship between equations and the physical processes that they describe.

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Geology 352: Introduction to Geophysics
Spring, 2007
Equation Dictionary Assignment

Geophysics is fundamentally based on mathematics, so you'll be seeing a lot of equations in this class. Many students approach equations simply by memorizing them, rather than focusing on what they tell you. A common question that I hear is "which equation should I use?" or "can I use this equation?" These questions suggest to me that there must be a better way to think about equations. My goal is for you to think of the equation as a story that describes the relationship between variables, or physical parameters. To that end, you will each put together an "equation dictionary" for this class. This dictionary will be yours to bring to exams (and it is the only thing you'll be allowed to bring, other than your calculator), so it is to your benefit to keep it organized and clear.

Each entry in your dictionary will contain 4 columns. The first column will be the equation itself. The second column will explain the variables in the equation. The third column will be a written description of what the equation is telling you, and how it is useful. The fourth column is available for additional comments of your choosing. For example, rather than simply writing down the equation

$$\beta = \sqrt{\frac{\mu}{\rho}}$$

You will have an entry in your dictionary that looks something like this:

Equation	Variables	Explanation	Comments
$\beta = \sqrt{\frac{\mu}{\rho}}$ Shear wave velocity	β → shear wave velocity (m/s) μ → shear modulus (Pa) ρ → density (kg/m^3)	The speed of a shear wave depends on the physical characteristics (shear modulus and density) of the material through which it is traveling. The more rigid the material, the faster the shear wave.	All other things being equal, velocity is inversely proportional to density. However, in general, if density increases, so do the elastic moduli.

Note that the explanation does NOT read "shear wave velocity is equal to the square root of the shear modulus divided by the density". That would just be turning the equation itself into words. Instead, you're presenting the equation in a way that gives it meaning and relates it to geophysical parameters and processes within the Earth.

Here's another example:

Equation	Variables	Explanation	Comments
$A = A_o e^{-\left(\frac{\varpi t}{2Q}\right)}$	A → seismic wave amplitude at time t A_o → initial amplitude of	The amplitude A of a seismic wave decreases as it travels. The	A high frequency wave attenuates more rapidly than a low frequency

Attenuation of seismic waves	the wave ω → angular frequency of the wave, also = $2\pi f$ t → time that the wave has been traveling and losing energy Q → quality factor; how much a wave attenuates (high Q = low attenuation!)	amount of attenuation depends on the frequency of the wave (how many times it oscillates per second), the time it has been traveling and the quality factor Q.	wave because it oscillates more times, generating more friction.

In this example you might also include other equations that describe attenuation, such as the version that depend on distance rather than time. This way they'd both be in the same place and you could compare which is most appropriate for a given problem. You might also want to include units in your dictionary.

You'll need to keep your dictionary organized for test days (so that you don't have to hunt through zillions of pages to find the equation you want). You may do this is any number of ways. I strongly recommend making a digital dictionary, since you can easily edit it and don't need to worry about losing it. It is also easier to organize. Equations are easy to write using Microsoft Equation 3.0 (in the text, click "insert/object and click on Microsoft Equation 3.0; I can give tutorials in this if you like). If you write your dictionary by hand, I recommend using a small (e.g. 5" x 7") 3-hole binder. This way you can add or remove equations when you want, and put them in a convenient order. You can divide the notebook into sections based on theme ("earthquake seismology", "refraction seismology", "gravity", etc), or arrange it chronologically.

I will check your equation dictionaries before each exam (please see the syllabus). 5% of your grade in the class will be based on your dictionary, and of course the better your dictionary is, the easier time you'll have on test days.