<u>EART162: Equations You Should Know</u> (in addition to high school physics)

Gravity

Grav. Force $F = G\frac{m_1 m_2}{r^2}$

Grav. potential $U = -G\frac{m}{r}$

Centripetal force $F = mr\omega^2$

Moment of inertia $I = \Sigma mr^2 = \int r^2 dm$

Uniform sphere $I = 0.4MR^2$

MoI difference $J_2 = \frac{C - A}{MR^2}$

Gravity formula $\Delta g = 2\pi G \Delta\rho h$
(42 mGal / km g cc^{-1})

Attenuation factor = exp *(-kz)*

Elasticity and Equations of State

Stress = *F/A* Strain = *ΔL/L*

Hooke's law $\sigma = E\varepsilon$

Definition of Poisson's ratio ν

Bulk modulus $\frac{d\rho}{\rho} = \frac{dP}{K}$

Hydrostatic assumption $dP = \rho g dz$

Viscosity

Viscosity definition $\sigma = \mu\dot{\varepsilon}$

Flow law $\dot{\varepsilon} = A g_s^{-p} \sigma^n \exp(-Q/RT)$

Flexure

Flexural rigidity $D = \frac{ET_e^3}{12(1-\nu^2)}$

Flexural parameter $\alpha = \left(\frac{4D}{(\rho_m - \rho_w)g}\right)^{1/4}$

Flexural equation $D\frac{d^4 w}{dx^4} + (\rho_m - \rho_w)gw = q(x)$

Seismology

P-wave velocity $V_p = \sqrt{\frac{K + \frac{4}{3}G}{\rho}}$

S-wave velocity $V_s = \sqrt{\frac{G}{\rho}}$

Heat Transfer

Fourier's law $F = k\frac{(T_2 - T_1)}{d} = k\frac{dT}{dz}$ 1D Heat Diffusion $\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} = \kappa\left(\frac{\partial^2 T}{\partial x^2}\right) + \frac{H}{C_p}$

Specific heat capacity $\Delta E = mC_p\Delta T$ Diffusivity $\kappa = \frac{k}{\rho C_p}$

Thermal expansion strain $\varepsilon = \alpha \Delta T$ **Diffusion timescale** $t \sim \frac{d^2}{\kappa}$

Fluid Flow

Viscosity $\sigma = \eta\dot{\varepsilon}$ Dynamic viscosity $\nu = \frac{\eta}{\rho}$

Navier-Stokes (Cartesian, in *y*-direction; gravity doesn't operate in *x*-direction)

$$\rho\frac{Du}{Dt} = -\frac{\partial P}{\partial y} + \eta\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) + \Delta\rho g$$

Reynolds number = $\frac{\rho u L}{\eta}$ Post-glacial rebound timescale $\tau \sim \frac{\eta}{\rho g L}$

Convection

Rayleigh number $Ra = \frac{\rho g \alpha \Delta T d^3}{\kappa\eta}$ Boundary layer $\delta = d(Ra^{-1/3})$

Tides and orbits

Orbital energy (per unit mass) = $-\frac{GM}{2a}$ Angular momentum = $na^2\sqrt{1-e^2}$ (per unit mass)

Equilibrium tide $H = R\frac{m}{M}\left(\frac{R}{a}\right)^3$ Love number $h_2 = \frac{5}{2}\frac{1}{(1+\frac{19\mu}{2\rho g R})}$