Geophysics 210 - 2008 Final exam - formula sheet

B : Gravity

Newtonian gravitation

Acceleration of gravity (*g*) due to a point mass (*m*) a distance (*r*) $g = \frac{Gm}{r^2}$

Gravity anomalies of sphere and cylinder

a = radius of sphere or cylinder

z = depth of the sphere or cylinder

G = 6.67 x 10^{-11} N m^2 kg^{-2}

M_S = excess mass

$\Delta\rho$ = density contrast

x = horizontal distance from sphere/cylinder

1 milligal = 10^{-5} ms^{-2}

$x_{½}$ = half width

Cylinder $g_z = \frac{2G\pi a^2 z\Delta\rho}{(x^2 + z^2)}$ $x_{½} = z$

Sphere $g_z = \frac{GM_S z}{(x^2 + z^2)^{\frac{3}{2}}}$ $x_{½} = 0.766z$

Free air correction

Change in g when elevation changes by *Δh* (*m*) $\Delta g_z = 0.3086\ \Delta h$ (milligals)

Gravitational attraction of a layer / Bouguer correction

Gravitational attraction of slab with thickness *Δz (m)* and density contrast *Δ ρ* *(kg m^{-3})*

$\Delta g_z = 2\pi G \Delta z\ \Delta\rho$ (ms^{-2})

Solar system data

Polar radius of the Earth	6356.7 km
Equatorial radius of the Earth	6378.1 km
Gravitational constant, G	6.67 10^{-11} N m^2 kg^{-2}
Mass of Earth, M_E	5.97 10^{24} kg
Mass of Moon, M_M	7.36 10^{22} kg
Mass of Sun, M_S	1.99 10^{30} kg
Earth-Moon distance	3.84 10^{5} km
Earth-Sun distance	1.50 10^{8} km

Isostacy

Airy hypothesis $r = h\ \rho_c / (\rho_m - \rho_c)$

ρ_c = crustal density ρ_m = mantle density

r = root depth h = mountain height

C: Seismology

v = velocity of seismic wave (m/s)	t = travel time (s)
x = source-receiver offset (m)	ρ = density (kg m^{-3})
f = frequency of seismic wave (Hz)	λ = wavelength (m)
$v = x / t$	
Seismic impedance , $Z = \rho v$	Seismic velocity, $v = f\lambda$

Reflection and refraction

Seismic wave travelling from layer 1 to layer 2, at normal incidence

Amplitude reflection coefficient, $R = \dfrac{Z_2 - Z_1}{Z_2 + Z_1}$

Amplitude transmission coefficient, $T = \dfrac{2Z_1}{Z_2 + Z_1}$

Snells Law

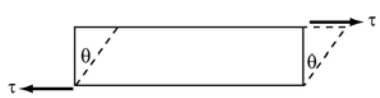
$$\frac{\sin\theta_i}{v_1} = \frac{\sin\theta_t}{v_2} = \frac{\sin\theta_r}{v_1}$$

Seismic wave in layer 1 is incident on interface at angle θ_i

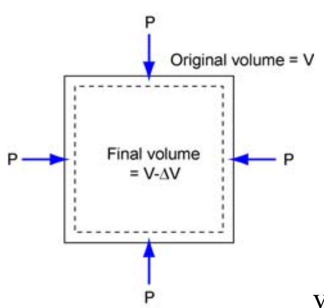
Reflected at angle θ_r in layer 1; Transmitted at angle θ_t in layer 2

Stress, strain

K = bulk modulus; μ = shear modulus; ρ = density



τ = shear stress; tan θ = shear strain; μ = τ / tan θ



volume stress = P; volume strain = $(\Delta V/V)$; K = P / (ΔV/V)

Seismic wave velocities

v_p= P-wave velocity v_s= S-wave velocity

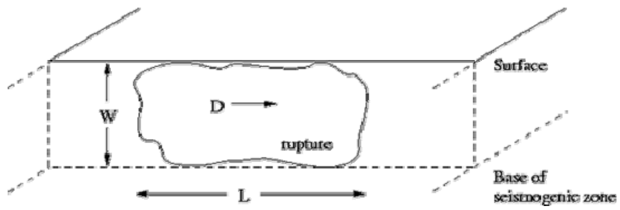
$$v_P = \left[\frac{K + \frac{4}{3}\mu}{\rho}\right]^{\frac{1}{2}} \qquad v_S = \left[\frac{\mu}{\rho}\right]^{\frac{1}{2}}$$

Earthquake magnitude

(1) Richter scale $M_S = \log_{10}\left(\frac{A_S}{T}\right) + 1.66\log_{10}\Delta + 3.3$

A_S	= amplitude of **surface wave** motion in microns
T	= period of surface wave (around 20 seconds)
Δ	= distance to earthquake epicentre (degrees)

(2) Moment magnitude



Seismic moment = $M_0 = \mu DA = \mu DLW$ where μ = shear modulus

Moment magnitude as $M_W = \frac{2}{3}\log_{10} M_0 - 6$

D: Geomagnetism

Dipolar magnetic field

M = dipole moment

$$B_r = \frac{2M\mu_0 \sin\theta}{4\pi r^3} \quad \text{and} \quad B_\theta \frac{M\mu_0\cos\theta}{4\pi r^3}$$

$$\tan I = 2\tan\theta$$

μ_0 = magnetic permeability = $4\pi\ 10^{-7}$ H/m

$$F(r,\theta) = \sqrt{B_r^2 + B_\theta^2} = \frac{M\mu_0\sqrt{3\sin^2\theta + 1}}{4\pi r^3}$$