1. Fill in the blanks.

a. The 1967 theoretical gravity equation describes how gravity varies on this equipotential surface. ________________

b. The slow variation of declination and inclination for Houghton, MI is known as ________________.

c. Modern-day gravimeters are of the (stable, unstable) _______________ type.

d. In these materials the spin magnetic moments of unpaired electrons between neighboring atoms are magnetically coupled but the moments are anti-parallel and equal ________________.

e. The propagation velocity and path of seismic waves are controlled by the _______________ and _______________ of the material through which they pass.

f. In electrical methods, resistance measured at the ground surface is controlled by lateral and vertical variations of electrical ________________.

g. The ________________ is a worldwide network of gravity stations where absolute values of gravity have been determined by reference to locations where absolute gravity has been determined using laser-interferometer free-fall gravity measuring systems.

h. This type of magnetism is reversible and has a positive magnetic susceptibility: ________________

i. Ferromagnetic materials lose their magnetization when the temperature of the material exceeds its _______________ temperature.

j. The ratio between the magnetism a rock acquires when placed in a magnetic field and the inducing field is termed ________________.

k. The phenomena of ground state splitting of electron energy levels in the presence of a magnetic field is known as the ________________.

l. Proton precession magnetometers measure which component of Earth's magnetic field? ________________

m. 1 mgal = __________ gu = __________ m/sec²
n. 1 nanotesla = ___________ gammas

p. This time perturbation of the Earth's magnetic field is associated with ionization of the upper atmosphere (ionosphere) by solar radiation in sympathy with tidal effects of the Sun and Moon: ________________________

q. Earth tides, spring creep or fatigue, and temperature variations cause gravimeters to experience a phenomena known as ____________________

2. How does Earth's gravity field differ from that of a uniform, stationary sphere that has the same mass?
3. Data reduction problem. Be sure to show your work.

<table>
<thead>
<tr>
<th>Station</th>
<th>Time</th>
<th>Reading (du)</th>
<th>Elevation (m)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE1</td>
<td>10:00 AM</td>
<td>1758.3</td>
<td>2175.6</td>
<td>41.20° S</td>
</tr>
<tr>
<td>U2</td>
<td>11:35 AM</td>
<td>703.3</td>
<td>2731.4</td>
<td>41.20° S</td>
</tr>
<tr>
<td>BE1</td>
<td>12:10 PM</td>
<td>1757.3</td>
<td>2175.6</td>
<td>41.20° S</td>
</tr>
<tr>
<td>U2</td>
<td>9:00 AM</td>
<td>933.3</td>
<td>2731.4</td>
<td>41.20° S</td>
</tr>
<tr>
<td>BY4</td>
<td>9:30 AM</td>
<td>364.3</td>
<td>3022.9</td>
<td>600 m North</td>
</tr>
<tr>
<td>U2</td>
<td>10:00 AM</td>
<td>934.3</td>
<td>2731.4</td>
<td>41.20° S</td>
</tr>
</tbody>
</table>

Gravimeter dial constant = 0.9645 gu/du

Bouguer reduction density = 2.20 Mg/m³

Observed gravity at base BE1 = 9,796,468.2 gu

Latitude of base BE1 = 41.20° S

Theoretical gravity at base BE1 = 9,802,762.1 gu

(a) What is the drift correction of station U2 for Day 1?

(b) What is observed gravity at station U2?

(c) What is the drift-corrected reading in dial units for station BY4 for Day 2 when using the 10:00 AM U2 reading to make the drift correction?

(d) What is the observed gravity at BY4?

(e) What is the value of theoretical gravity at BY4?

(f) What are the simple Bouguer gravity and the Free-Air anomalies at station U2?

4. Geophysical measurements (methods) can be classified into two distinct types. What are they and give an example of each?
5. Fluxgate magnetometers are sometimes refer to as vector magnetometers while cesium vapor and proton precession magnetometers are know as scalar magnetometers. Why?

6. Currently, Earth's geomagnetic poles are located at 79.3 °N, 71.5 °W (north pole) and 79.3 °S, 108.5 °E (south pole) while the magnetic dip poles are located at 79.0 °N, 105.1 °W (magnetic north) and 64.7 °S, 138.6 °E (magnetic south). Why the difference?

7. What is the maximum error allowable in north/south location and elevation at 26.6 °N latitude to achieve a 0.1 gu accuracy in calculating the simple Bouguer anomaly of a gravity station hen the near surface density is 2.75 Mg/m³.
8. What are the 3 vectors and 2 angles used to describe Earth's magnetic field at a given location. Draw a diagram illustrating their relationships to each other. What are the values for the two angles of the field for a site located at 26.6 °S when the field conforms to a geocentric axial dipole.
9. The gravity data shown below were collected to determine whether an abandon coal mine underlies this area which has been proposed for a new housing development on the outskirts of Golden, CO. Draw in the regional. Do any of the residuals suggest the presence of an abandon mine tunnel. If so, which one? What type of geometric model would you use to model the residual?

![Graph showing gravity data with distance (m) on the x-axis and delta g (mgal) on the y-axis. The graph shows a peak at approximately 150 m, suggesting possible tunnel presence.](image-url)
Equation Sheet

\[ F = \frac{G m_1 m_2}{r^2} \quad g = \frac{G m_1}{r^2} \quad F = \frac{\mu_0 \rho_1 \rho_2}{4 \pi \mu r^2} \quad B = \frac{\mu_0 \rho_1}{4 \pi \mu r^2} \] where \( p \) = pole strength

\[ G = 6.67 \times 10^{-11} \text{m}^3/\text{kg-sec}^2 \quad GM = 3.986005 \times 10^{14} \text{m}^3/\text{sec}^2 \quad \omega = \frac{2\pi}{T} \]

\[ g_{th} = 9780318.46(1 + 0.005278895 \sin^2 \lambda + 0.000023462 \sin^4 \lambda) \text{ gu} \]

Free Air correction: \( C_{FA} \) (gu) = 3.086 h (m)
Bouguer slab correction: \( C_{FA} \) (gu) = 0.4191ph (m) where \( \rho \) is in Mg/m^3
Theoretical gravity gradient:: \( \Delta g_{th} = 8.11 \times 10^{-3} \sin 2\lambda \Delta s \) (m)
Terrain correction: \( C_T \) (gu) = 0.4191 \( \rho/n (r_2 - r_1 + \sqrt{r_1^2 + z^2} + \sqrt{r_2^2 + z^2}) \)

where \( C_T \) = terrain correction of a sector; \( \rho \) = Bouguer reduction density (Mg/m^3); \( n \) = number of sectors in a zone; \( r_1 \) = inner radius of zone (m); \( r_2 \) = outer radius of zone (m); and \( z \) = modulus of elevation difference between observation point and mean elevation of the sector (m).

\[ g = 4\pi^2 l / T^2 \quad g_1 T_1^2 = g_2 T_2^2 \quad g = 2(s_2 t_1 - s_1 t_2) / t_2 t_1 \]

\[ R = R_o (1 - f \sin^2 \lambda) \quad f = 1/298.247 \quad R_o = 6,378,139 \text{ m} \quad R_{ave} = 6.371,000 \text{ m} \]

\[ \tan I = 2 \cot \rho = 2 \tan \lambda \]

\[ |B| = \sqrt{B_r^2 + B_\theta^2} = (\mu_0 m/4\pi r^3)(4 \cos^2 \rho + \sin^2 \rho)^{1/2} \]

\[ B_r = 2(\mu_0 m/4\pi r^3) \cos \rho = 2(\mu_0 m/4\pi r^3) \sin \lambda \]

\[ B_\theta = (\mu_0 m/4\pi r^3) \sin \rho = (\mu_0 m/4\pi r^3) \cos \lambda \]

\[ B = \mu_0 H + \mu_0 J_l \quad B = \mu H \quad \mu = \mu_0 \mu_r \quad \mu_r = 1 + k \]

\[ \mu_0 = 4\pi \times 10^{-7} \text{ webers/Am} \]

\[ X^2 + Y^2 + Z^2 = T^2 \quad X^2 + Y^2 = H^2 \quad \Delta T = \Delta H \cos I_0 + \Delta Z \sin I_0 \]

\[ H = T \cos I; \quad Z = T \sin I; \quad Z = \tan I \]

\[ \tan D = Y/X; \quad X = H \cos D; \quad Y = H \sin D \]