**Homework 2**

Professor: PhD. Eunseo Choi

Student: Evelyn Susana Delgado Andino

[*dlgdndno@memphis.edu*](mailto:dlgdndno@memphis.edu)

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| Part 1: Cavendish’s Experiment |

Cavendish's experiment consists of a torsion balance (originally created by John Michell, who died without completing his experiments) that tests the balance between gravitational and torsional forces. Cavendish did not initially use the machine to measure the gravitational constant, but his first measurements were aimed at determining the mass of the Earth.

The fundamental equilibrium equation present in the experiment is Newton's law of universal gravitation. The equilibrium condition is reached when the torque due to the gravitational force between the large and small masses balances the torque due to the torsion wire. In this case, the equation that describes the equilibrium is:

Where is the length of the torsion balance beam, is the gravitational force between the large and small masses, is the angular deflection of the torsion balance, and is the torsion coefficient of the wire. If we measure the oscillation period of the Cavendish torsion balance, we can find the following relationship between the moment of inertia and the torsion coefficient. We write the next equation:

For the two small masses the moment of inertia at a distance from the axis of rotation is:

Substituting

Using the fundamental force balance equation, and Newton's law of gravitation:

Then

Finally,

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| Part 2: Obtain the free-air and Bouguer gravity anomalies |

The surface gravity at a measuring site is . The site has a latitude and an elevation of. Obtain the free air and Bouguer gravity anomalies. Ignore the tidal and terrain corrections.

Resolution:

In both anomalies we need the value of normal gravity:

Where is equal to , is equal to ,correspond to the equator gravity that is and is the latitud in radians. For this specific case the value of is given by:

Then

Another value that we need in both anomalies is the free air correction which is given by:

Where is the mean gravity, is the Earth’s radius, and is altitude at a given point. The factor has the value of per meter of elevation.

**Free-air anomaly**

The equation for this anomaly is:

Following the directions we will ignore the tidal and terrain corrections.

**Bouguer anomaly**

In addition to the values, ​​we already have, we must calculate the Bouguer plate correction:

The average density of the crust will be used,

Now, the calculation of the Bouguer anomaly is as follows:

Ignoring tidal and terrain corrections.

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| Part 3: Qualitatively description of the profiles of geoid |

Diagram of lithosphere and lithosphere

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If there is a plume, which we know is hot material that rises due to the difference in density compared to the colder material in the mantle, gravity anomaly may occur in that area. This is broadly one of the ideas proposed by Fowler (2012) in section 5.6.2.

For the two cases presented here, we can make the following analysis:

First case: In this case, the ascending plume does not push the lithosphere. As mentioned by Fowler (2012), in some instances, topography helps counteract the density difference caused by the lower density material. However, in this case, there is no compensation, so a negative gravity anomaly would be observed.

Second case: in this case, a bulge is observed due to the upward push of the mantle column. We can see that the density deficit due to the hot mantle material is maintained, there is also a contribution from topography, which can lead to higher gravity values ​​near the topographic bulge. However, the Bouguer anomaly could still be negative, depending on whether the topographic effect is able to completely counteract the low-density effect in the area.

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| Part 4: |

A close-up of a map

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**Solving a)**

According to the Airy isostasy model, the pressure at the base of the continental crust is equal to the pressure at the base of the oceanic crust, so the equilibrium equation for pressures could be written as:

Where is the crust density, correspond to the density sea water, is the density of the mantle, is the total crustal thickness of , and is the thickness of crust above seafloor. Solving the equation for .

Replacing the values

**Solving b)**

Two expressions will be written, one for the “above" thin sheet and another for "below" thin sheet. To do this the formula that will be used is:

Where is the gravity anomaly, is the density contrast, , is the thickness of the sheet, is horizontal distance from the observation point, and correspond to the depth of the sheet. Above seafloor level , and below seafloor level

**For the “above" thin sheet**

We use because the sheet is located at the middle depth, and corresponds to the thickness.

**For the “below" thin sheet**

In this case we use because we need the portion in the middle depth of the portion below seafloor that is , but it is necessary add to have the distance from the seafloor to sea level.

**Solving c) (code in Jupiter Notebook)**

A graph of a graph

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Solving d) **(code in Jupiter Notebook)**

A graph of a graph

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**Solving e) (code in Jupiter Notebook)**

A graph of a graph

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**Solving f) (code in Jupiter Notebook)**

A graph of a graph

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**References**

Lowrie, W. (2007). Fundamentals of geophysics (2nd ed.). Cambridge University Press.

Fowler, C. M. R. (2005). The solid Earth: An introduction to global geophysics (2nd ed.). Cambridge University Press.