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12.002 Physics and Chemistry of the Earth and Terrestrial Planets
Fall 2008

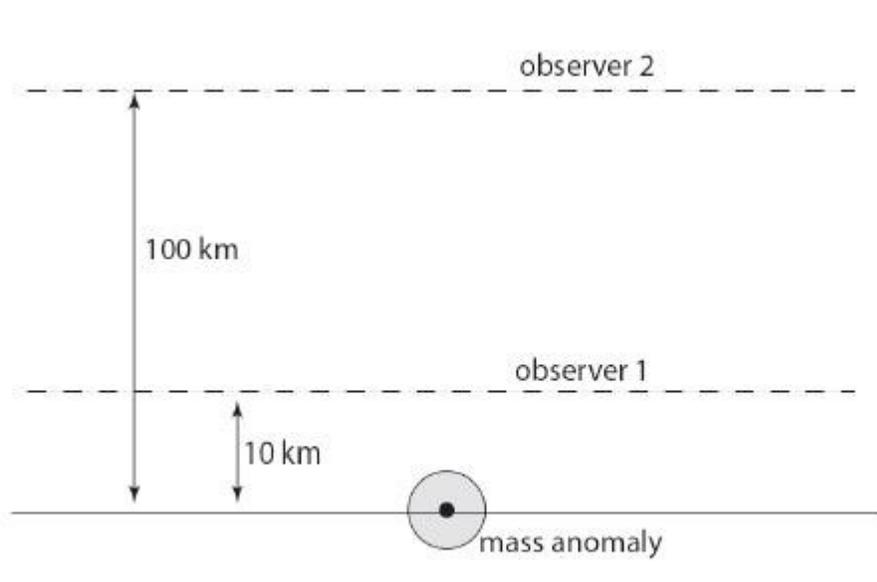
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Problem Set #9: Gravity
due Friday Dec 5 in class

Problem 1.

With increasing distance between a mass and an observer, a gravity signal is “spread out” so that the amplitude of the anomaly becomes smaller while its width becomes larger. This can be illustrated by considering a line mass, extending to infinity in the y-direction.

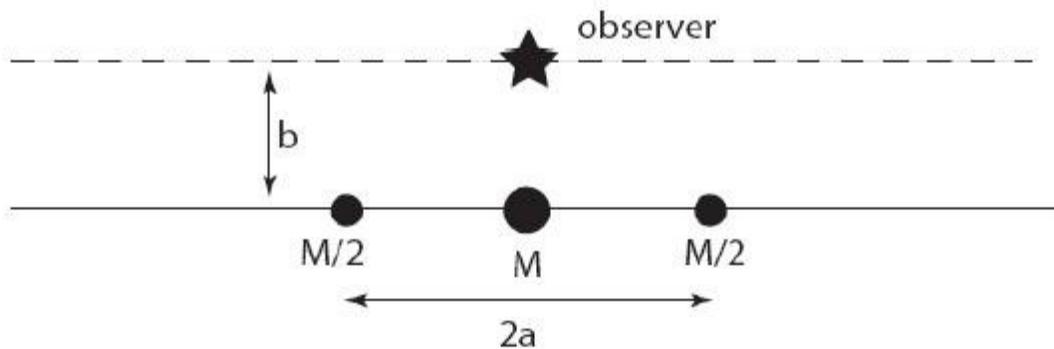
Plot, for all values of x (until field reaches insignificant values) the gravity anomaly (Free-air, or total anomaly measured at a uniform elevation) for an infinite cylinder with a density anomaly of $+500 \text{ kg/m}^3$ and a radius of 1 km. This mass distribution can be approximately equated with a line mass anomaly coinciding with the center of the cylinder. Plot the gravity anomaly, as a function of x , measured by an observer at a distance of 10 km and at 100 km. Plot them on the same graph. What do you notice about the relative size/width of the anomaly?



Problem 2.

Because gravity signals “spread out” with increasing distance from the source, there is a limitation as to how well one can measure narrow, spatially-localized mass anomalies from a spacecraft. Consider two cases, one of a line mass, with mass m per unit length; the second with two line masses each with mass $m/2$ per unit length, and separated from one another by a distance $2a$.

- Suppose the observer is located at a height b above the masses. If b is very large compared to a , the gravity anomalies for the two cases will be virtually indistinguishable. As the distance between the observer and the masses is decreased, at what value of b will the maximum value of the measured gravity (measured directly above the line mass and above the midpoint between the two line masses) differ by (i) 1%? (ii) 5%? by (iii) 25%?
- Plot the gravity anomaly (in some units) for the both cases for (ii). Plot them on the same axis.
- Use the results of this problem to comment, quantitatively, on what you can observe from gravity data collected by a satellite flying at an altitude of 300 km above a planetary surface.



Problem 3. Compensated Topography

- a) Plot the gravity anomalies generated by a plateau that is 2 km high and 500 km wide if the plateau is Airy compensated at 30 km depth and the observer is at an elevation of 5 km (in a Star Wars jet craft). (Use the equation for a strip load with a crustal density of 2800 kg/m^3 and a mantle density of 3300 kg/m^3 .)
- b) the same as (a) but put the observer 150 km above the ground.

Problem 4. Uncompensated Topography

- a) Plot the gravity anomalies generated by a crater that is 1 km deep and 200 km wide if the crater is totally uncompensated (ie flat Moho, no mass anomaly below, held up by very strong lithosphere) and the observer is at an elevation of 5 km. (Use the equation for a strip load with a crustal density of 2800 kg/m^3 .)
- b) the same as (a) but put the observer 150 km above the ground.

Problem 5.

Look at the topography of Venus and the Moon that was handed out in class (colored maps) and comment on whether the Moon's craters and highlands and Venus' highlands are compensated, uncompensated, or related to some other density distribution at depth.