Geophysics 150: Homework 4
(Due February 24 2005)

This problem set involves gravity. One can either use the MKS value of G , 6.67 nt m^2 kg^{-2} or use geologists' units where $2\pi G = 42$ mgal km^{-1} $(gm/cc)^{-1}$. A mgal is 10^{-5} m s^{-2} or about 1 part per million of the Earth's surface gravity. It comes from the cgs unit gal = 1 cm s^{-2}.

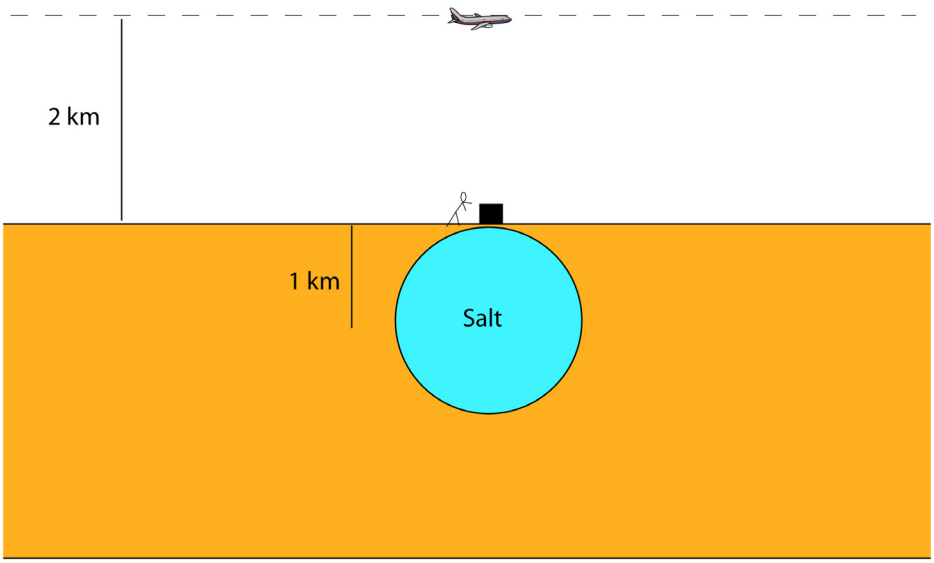
1. Geophysicists usually ignore the effect of the air. Let's see if this is OK.

a. You are measuring gravity in the eye of a hurricane. The air pressure is lower than the typical air pressure by one tenth below its normal value in fair weather. Making very simple assumptions (which would not please a meteorologist) this is equivalent to removing layer of 1-m thickness and 1 gm/cc above your instrument. What is the change in gravity from the reduced amount of air? Your gravimeter measures downward pull. Explain the sign of the change from fair weather to the hurricane.

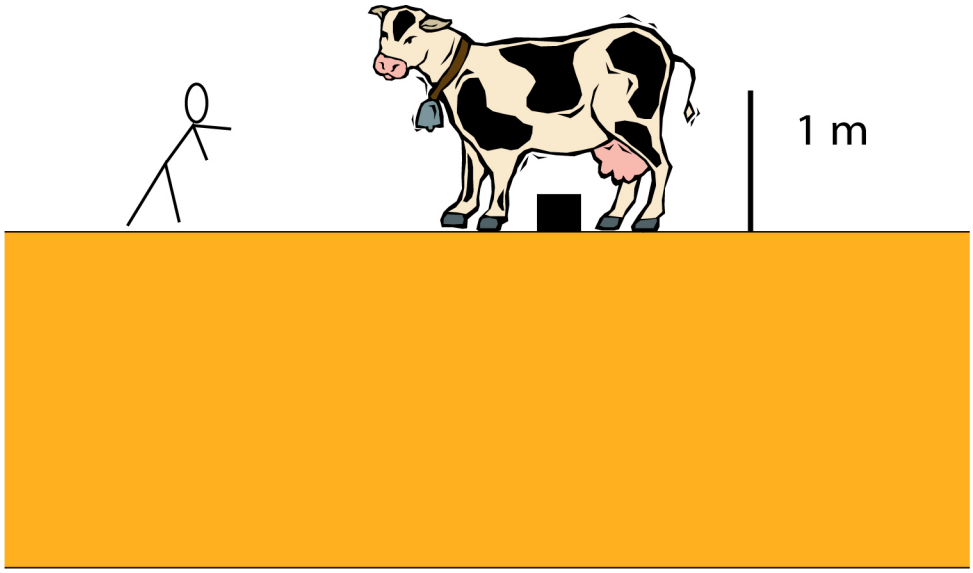
b. You wish to compare gravity data from a satellite (elevation 100 km) above the atmosphere with data on the ground. Consider just the effect of the mass of the air. Treat the air as a spherical shell. Computer its gravity effect on the satellite and on the ground. The air is equivalent to a 10-m thick shell with a density of 1 gm/cc.

c. Repeat the calculation incorrectly modeling the air as an infinite flat sheet. Compare the two differences.

2. We get worried sometimes about the effect of small objects on gravity. We need to start with the large body we are trying to find. You are measuring gravity above a salt dome that we will treat a 1-km diameter sphere centered 1-km beneath you. Its density difference with the surrounding rocks is 0.4 gm/cc.



a. We are interested on whether we can detect the body. We can measure gravity to 0.1 mgal and geoid height to 0.1 m. Compute the difference in gravity and geoid from a point directly over the body relative to a point far away.



b. A curious cow comes by. Its mass is 500 kg. It gets directly above your meter. Assume a spherical cow with its center 1-m above the instrument. What is the gravity effect of the cow and the sign.

c. You have instead a gravity gradiometer. Compute the effect of the salt dome and the cow where you are measuring. Do you need to worry about the cow now?

3. We make "corrections" on gravity data. Let's see the logic of why we do this. You also measure gravity 2 km up above the center of the salt dome. Assume that that you are at 30° latitude and that your first ground measurement was at sealevel.

a. The free air anomaly on the ground is 20 mgal. Use the 1967 formula on page 90 of the book to get the expected sealevel gravity and then obtain the gravity reading at the surface.

b. What is the change in gravity from your 2-km up station being farther from the center of the Earth? Explain the sign. Ignore the effect of the air.

c. What is the effect from being further from the center of the salt dome? Explain sign.

d. Combine results to get gravity reading at 2-km elevation. Get free air anomaly. Sketch free air anomalies across salt dome at surface and 2-km up.