Geophysics 4133
Gravity Basics
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Name: _____

For each of the following problems neatly show all steps of your work (partial credit may be given if your work can be easily followed). Clearly indicate your final answers and answer all parts of the question including the 'describe' and 'why' questions.

1. When Neil Armstrong stepped foot on the moon his mass was the same as it was on Earth (60kg). What was his weight (in Newtons)? By what percentage was his weight reduced compared to when he was standing on Earth? Hints: $M_{moon} = 7.4x10^{22}$kg and $r_{moon} = 1738km$ *15 pt.)*

2. The Mars Reconnaissance Orbiter attained an altitude of 426 km from the planet's surface at periaps (closest to the surface) after orbital insertion. The orbiter weighed approximately 2000 kg. Mars has a mass of $6.4185x10^{23}$kg and a radius of about 3386.2 km. What is the magnitude of the force of gravity between the orbiter and the planet? *(10 pt.)*

3. In 1672 Jean Richter took a pendulum clock from Paris to Cayenne as part of a study. He soon discovered that his clock was losing 2.5 minutes each day. Knowing that the acceleration of gravity was 9.80901 ms^{-2} in Paris, what was it in Cayenne? *(15 pt.)*
   Hint: $\tau \simeq 2\pi\sqrt{\frac{l}{g}}$

4. The magnitude of the acceleration of gravity is affected at the poles by two factors: the radius of the Earth at the poles is less than at the equator (reducing the radius term in Newton's 4^{th} law) and there is less centrifugal acceleration at the poles. When all terms are considered the gravitational acceleration at the poles is about 0.05186 m s^{-2} more than at the equator. *(30 pt.)*

   a) Consider only the difference in radius of the Earth ($R_{equator} = 6,378,137$ m and $R_{pole} = 6,356,752$ m)

b) Consider only rotation of the planet. What is the difference between gravitational acceleration at the equator and the non-rotating poles? Hint: Angular speed = $\frac{2\pi}{time}$ and one sideral day is 23 hours, 56 minutes, and 4.1 seconds.

5. The Joplin, MO area is full of mineshafts and crosscuts from the days of coal exploration. In the years since these mines were active, many of the entrances have become unsafe, but their location has been lost. You are hired to consult and attempt to locate the mines with gravity data. The mines are filled with air ($\rho_{air} = 1.23 kgm^{-3}$) and the country rock has a density of approximately 3000 kg m^{-3}. Most of the crosscuts are only about 2.5 m in diameter. How close to the surface must the tunnels be to be detected by a gravity survey with 0.1mgal accuracy? The tunnels may be considered as horizontal cylinders. *(15 pt.)*

6. A common gold mining practice is to create stopes, or vertical tunnels that run upwards several hundreds of feet. Consider a stope that begins 300m below ground and runs vertically to within 100m of the surface. The stope is cylindrically shaped with a diameter of 4m. What is the maximum expected gravity anomaly? *(15 pt.)*