# ASTR/GEOL-2040-001: Search for Life in the Universe

Homework #6 Due: Friday November 3, 2017

Remember to show all details of your work and staple your pages! Don't use this homework page to squeeze your answers on the margins or between the lines.

1. **How big a rocky core does Titan have?** Titan has a mass of $M = 1.346 \times 10^{23}\,\mathrm{kg}$ and a radius of $R = 2,576\,\mathrm{km}$.

(i) Compute Titan's volume, $V = \frac{4\pi}{3}R^3$. What is Titan's mean density, $\overline{\rho} = M/V$? [Show the details of your work!] [2pts]

(ii) Your result above should lie somewhere between the mean densities of rock, $\rho_{\mathrm{rock}} = 3100\,\mathrm{kg\,m^{-3}}$, and ice, $\rho_{\mathrm{ice}} = 950\,\mathrm{kg\,m^{-3}}$. Explain why? [2pts]

(iii) Assume that Titan is composed of 50% rock and 50% ice, what would the mean density be? Compare this with the mean density of Titan. [2pts]

(iv) Assume that half of Titan's volume consists of rock, what would the radius $R_{\mathrm{rock}}$ of such a rocky core be? Check that its volume $V_{\mathrm{rock}} = \frac{4\pi}{3}R_{\mathrm{rock}}^3$ is indeed half of Titan's value that you computed in (i). [2pts]

(v) Now assume that Titan is composed of 40% rock and 60% ice, what would the mean density be? Again, compare this with the mean density of Titan. [2pts]

(vi) Do you expect the fraction of rock in Titan to be more or less than 40%? [2pts]

2. **Planetary protection categories.** Place each of the following five space missions in the appropriate planetary protection category (I to V, with V being the most restrictive), giving the reason for each case.

(i) cometary nucleus lander, [2pts]

(ii) Mercury orbiter mission, [2pts]

(iii) Jupiter orbiter with Mars fly-by en route, [2pts]

(iv) Mars orbiter and lander, [2pts]

(v) mission to return cometary dust to Earth. [2pts]

3. **Is the water in Lake Vostok salty or fresh?** Lake Vostok beneath the ice of Antarctica is believed to be a good analog of Europa's ocean. However, Lake Vostok has fresh water and Europa's ocean is salty. This makes the density of Europa's ocean bigger than that of Lake Vostok.

Think of the ice as floating rafts. Read Box 4.7 of the text book by Rothery et al. on page 157. In the sketch below you see two identical ice rafts, but they are floating in media of different density, $\rho_{\mathrm{I}}$ and $\rho_{\mathrm{II}}$. Which one corresponds to Lake Vostok and which one to Europa's ocean? Explain your answer. [6pts]