

## Space Systems Question – Field Exam 2012

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1. Asteroids: The definition of a Potentially Hazardous Object (PHO) is one that comes within 0.05 astronomical units (AU) of the Earth, and has a diameter greater than 150 m.
  - a. Define eccentricity.
  - b. Define semi-major axis.
  - c. Derive an expression for eccentricity for an elliptical orbit.
  - d. If the Earth's semi-major axis is 1.00000261 AU and Earth's eccentricity is 0.01671123, what is the Earth's perihelion and aphelion?
  - e. The asteroid 1999 RQ36 has a semi-major axis of 1.126 AU and eccentricity of 0.204. What is the asteroid's perihelion and aphelion?
  - f. Asteroid 1999 RQ36 has an estimated density of  $1500 \text{ kg/m}^3$  and an estimated mass of  $1.4 \times 10^{11} \text{ kg}$ . Is 1999 RQ36 a PHO?
  - g. The solar constant is  $1.361 \text{ kW/m}^2$ . Consider a spacecraft orbiting the asteroid such that the spacecraft casts a shadow on the asteroid surface. Use the asteroid diameter you obtained from part (f), your guess at the cross section of an asteroid-chasing spacecraft, and your guess at the albedo of asteroid 1999 RQ36 to estimate the thermal flux incident on a spacecraft. As a reference, the albedo of the Earth is 0.3.
  
2. OSIRIS-REx is the first US asteroid sampling mission, due to launch in 2016. As part of the mission's educational program, MIT students will design, build, test and deliver REXIS, an x-ray imaging spectrometer, to the program. Below is a list of standard spacecraft subsystems for OSIRIS-REx.
  - a. *Briefly* describe the general function of each subsystem and what components you might use to implement each subsystem on an asteroid sample return mission like OSIRIS-REx.
  - b. What kind of interaction would the REXIS instrument require from each subsystem during the mission?
    - i. Power
    - ii. Thermal
    - iii. ADCS
    - iv. Avionics
    - v. Communications
  - c. What is the difference between EMI (electromagnetic interference) and EMC (electromagnetic compatibility)?
    - i. Give two examples of EMI and a mitigation strategy for each.
  
3. Thermal Systems
  - a. Describe thermal radiation, convection, and conduction. Which are likely to be most effective for spacecraft system thermal management? If your spacecraft is running hotter or colder than expected during integration and test, what would you do? If your spacecraft is running hotter or colder than expected during on-orbit operations, what would you do?
  - b. What is the temperature of deep space?
  - c. How can we emulate deep space in a thermal vacuum chamber (TVAC)?
    - i. How does a TVAC get cold?

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- ii. How does a TVAC heat up?
  - d. What is room temperature?
  - e. What is the temperature of liquid nitrogen?
  - f. What is the temperature of liquid helium?
  
  - g. Which would you use in your TVAC? Use the Stefan-Boltzmann law (the relationship between radiated energy and temperature) to help justify your answer.
4. Programmatic
- a. Name at least three categories of risk that should be considered during the development of a space flight program.
  - b. Describe how you would use testing to mitigate each of these risks.
  - c. How would you decide when a risk has been sufficiently reduced? How would you manage risks while reducing the impact on cost and schedule?
  - d. Give an example of a mission failure and how it might have been avoided during development.