ECE 6390: Satellite Communications and Navigation Systems
Solutions to TEST 1 (Fall 2007)

1. **Short Answer Section**

   (a) radioisotope thermal generator (RTGs), batteries, solar cells, fuel cells.

   (b) Sputnik

2. **Plane Wave Equations:**

   You measure the time-harmonic electric field around an earth station to be:

$$\tilde{\vec{E}}(\vec{r}) = 10[\hat{x} + \hat{y}] \exp\left(-j\left[\hat{x} - \hat{y} - \hat{z}\right] \cdot \vec{r}\right) \text{ mV/m (in free space)}$$

   Answer the following questions based on this measured field value:

   (a) Magnetic field:

$$\tilde{\vec{H}}(\vec{r}) = 37.5\left[\frac{1}{\sqrt{6}}\hat{x} - \frac{1}{\sqrt{6}}\hat{y} + \frac{2}{\sqrt{6}}\hat{z}\right] \exp\left(-j\sqrt{3}\left[\frac{1}{\sqrt{3}}\hat{x} - \frac{1}{\sqrt{3}}\hat{y} - \frac{1}{\sqrt{3}}\hat{z}\right] \cdot \vec{r}\right) \mu\text{A/m}$$

   (b) If $k = \sqrt{3}$, then $\lambda = 3.6$m.

   (c) Azimuth: 315°, Elevation: 35.3°.

3. **Deep Space Orbits:** The total time is 1.50×10^8 seconds or 4 years and 9.2 months. This would place arrival time at Jupiter in mid-May of 2016. Despite our crude approximations, this puts us pretty close to the actual mission arrival time of 19 October 2016. The error is due to acceleration periods due to spacecraft thrusting, some not-exactly-half-or-full orbital periods in the actual geometry, as well as a couple special mid-journey adjustments in trajectory.

   The value for R_{aph} results in an orbital period that is an integer multiple (2) of Earth's period, ensuring that Earth has returned to the same spot along with the spacecraft to actually perform the slingshot!

4. **Link Budget for Neptunian Probe:** The planet Neptune is 4.45×10^9 km from Earth at the time a NASA space probe must communicate back to an earth station using a 28 GHz carrier with a minimum received power of -110 dBm. Based on this scenario, answer the following questions.

   (a) $P_T = 272$ kW (a bit much for a deep space mission)

(b) $G_T = 68.7$ dBi

(c) The larger dish resulting from higher gain will result in a heavier, unwieldy spacecraft; the increased gain will also decrease beamwidth and make pointing back to earth more difficult.

(d) A higher-powered amplifier will use more power, which may not be available on the spacecraft.