ECE 6390: Satellite Communications and Navigation Systems
Solutions to TEST 1 (Fall 2009)

1. **Short Answer Section**

   (a) RTG (radio-isotope thermoelectric generator)

   (b) True

   (c) source-free

   (d) transponder

   (e) xenon

2. **Polar Orbit:**

   (a) Given apogee is 30×10^6m and perigee is 6.9×10^6m, which means that the semi-major axis a is 18.5×10^6m. Using Kepler's second law, we find that

   $$T = \sqrt{\frac{4\pi^2 a^3}{GM_p}} = 25{,}000 \text{ seconds}$$

   or about 6 hours and 57 minutes.

   (b) The eccentricity formula can be rearranged to

   $$e = \frac{\text{apogee} - \text{perigee}}{\text{apogee} + \text{perigee}} = 0.63$$

   (c) 13.3°

3. **Satellite Conspiracy Theory:**

   (a) This resembles the homework problem with the dish relay in that the total link budget is like two link budgets "glued" together. The power-up link budget requires the following power (linear scale parameters: $G_T = 10$, $G_R = 1$, $P_R = 20\mu$W, $\lambda = 0.3$m at 915 MHz):

   $$P_T = \frac{(4\pi r)^2 P_R}{G_T G_R \lambda^2} = 732 \text{ MegaWatts}$$

   which is a ridiculous amount of power for a satellite.

(b) For retrieving information, we require 10^{-13} Watts of received power in a double link:

$$P_T = \frac{(4\pi r)^4 P_R}{G_T^2 G_R^2 \lambda^4} = 134 \text{ TeraWatts}$$

which is totally redonk.

4. **Plane Waves:**

(a) angles-of-arrival: azimuth 270°, elevation 45°

(b) Magnetic field expression is given by

$$\tilde{\vec{\mathrm{H}}}(\vec{\mathrm{r}}) = -375\hat{\mathrm{y}} \exp(-j60[\hat{\mathrm{x}} - \hat{\mathrm{z}}] \cdot \vec{\mathrm{r}})\, n\mathrm{A/m}$$

(c) 4.1 GHz

(d) The power density of the plane wave (from the Poynting vector) is 18.8×10^{12} W/m^2, for a total received power of 37.5 pW.