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

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

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:

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

which is totally redonk.

4. Plane Waves:

(a) angles-of-arrival: azimuth $270^\circ$, elevation $45^\circ$

(b) Magnetic field expression is given by

$$\tilde{\mathbf{H}}(\mathbf{r}) = -375\hat{y} \exp(-j 60[\hat{x} - \hat{z}] \cdot \mathbf{r}) \text{nA/m}$$

(c) $4.1 \text{ GHz}$

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