ECE 6390: Satellite Communications and Navigation Systems
Solutions to TEST 1 (Fall 2010)

1. Short Answer Section:

   (a) RTG

   (b) Batteries

   (c) equatorial, zero, period

   (d) moon

   (e) false (...when escape velocity is exceeded)

   (f) ion

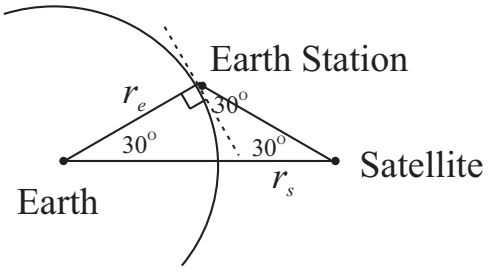
   (g) oblations

   (h) equator

2. **Look Angles:**

   (a) Lat 0°, Lon −84°

   (b) Drawing this scenario as a 2D slice through the −84° longitudinal plane reveals the geometry formula you need to solve for the satellite radius, r_s:



$$r_s = \sqrt{3} r_e = 11050 \text{ km}$$

(c) A geosynchronous satellite will have a period of approximately 86,164s (you could use a solar day value here and get the virtually the same answer, since the sidereal day was not supplied) and a semi-major axis of 42,163 km. Since perigee is related to semi-major axis by the formula $\rho_p = (1 - e)a$, we can calculate the eccentricity to be 0.74.

3. **Moon-based Bent Pipe Transponders:**

(a) Using Kepler's second law and assuming a perfectly circular orbit results in a radius of 392,000 km.

(b) There are a number of plausible answers here that would receive full credit, including:

i. launching to the moon is prohibitively more expensive than to GEO

ii. satellites typically need uninterrupted solar illumination, which is not available on the moon

iii. the additional propagation losses (around +20 dB) would require much more transmit power

Other well-reasoned answers were accepted, but they had to be of comparable consequence.

Answers that were less consequential, particularly if they related to concepts that were not covered by the course period, were not given full credit. If you did not follow directions and gave me more than two reasons, I graded the first two and ignored the rest. If you hallucinated your own question and answered it (for example, *What are two engineering reasons that might prohibit practical bent-pipe transponders from being placed anywhere in space?*) instead of answering the given question, you did not receive points. Answers that involved parroting given information in the problem statement back to me (e.g. the satellite would not be geostationary) were also not given credit. If you did not complete your thought ("The moon is far away." *so...*), points were also deducted.

4. **Satellite-to-Satellite Relay:**

(a) If the antennas on transmit and receive are identical, then each must have at least 34 dBi peak gain in order to receive at least -80 dBm in the link. This leads to an electromagnetic aperture of 0.047 m^2 and a diameter of 24.6cm.

(b) Interpretation for this problem varied wildly, but any answer that reasoned from a correct half-power beamwidth calculation received full credit. One could argue that, as long as both satellites were pointed within their 3 dB half-power beamwidth, there would always be greater than 0 dB of margin in the radio link. HPBW is calculated by

$$\theta_{\text{HPBW}} \approx \sqrt{\frac{30,000}{G}}$$