# ECE 6390: Satellite Communications and Navigation Systems
# Solutions to TEST 2 (Summer 2015)

1. **Dish Antennas and Noise:**

   (a) For a dish with peak gain of 400,000 (56 dBi), $G/T = 400,000/T_{sys} = 2,000K^{-1}$, which implies $T_{sys} = 200$ K. If the physical temperature in open sky is 50 K, then the device temperature of the LNA must be approximately 150 K (neglecting the effects of any other RF devices).

   (b) NF $= (1 + T_d/T_o) = 1.8$ dB

   (c) $Pr = 10 \log 10(kTB) + 30 + 12 =$-104.8 dBm

   (d) $D = 2\sqrt{\frac{G\lambda^2}{4\pi^2}} = 6.0$ m

   (e) $\theta_{\text{HPBW}} = \sqrt{\frac{30,000}{G}} = 0.27$ degrees

   (f) $\sigma_h < \frac{\lambda}{8} = 3.7$ mm

   (g) Peak gain drops slightly, some sidelobes increase dramatically

2. **Interplanetary Doppler:**

   This looks like a hard problem unless you realize that the planetary motion is orthogonal to the direction of wave propagation. Thus, there is no need to worry about the speed of Jupiter or Earth around the sun. If we view the satellite orbiting Jupiter as a transmitter, then the maximum Doppler contribution will occur when the satellite's circular orbit velocity is aligned towards or away from Earth:

   $$|f_{DT}|_{\text{max}} = \frac{V_T}{\lambda} = 1.052 \text{ MHz} \qquad V_T = \sqrt{\frac{GM_J}{R}} = 39,463 \text{ m/s}$$

   One more thing to consider: the earth station receiver will be rotating which contributes a Doppler shift at the receiver (maximized at sunset and sunrise):

   $$|f_{DR}|_{\text{max}} = \frac{V_R}{\lambda} = 1.24 \text{ kHz} \qquad V_R = \frac{2\pi R_E}{T_{\text{day}}} = 465 \text{ m/s}$$

   This contribution is significantly less than the transmitter-induced Doppler shift. Based on these numbers, an Earth receiver must be prepared to receive a signal for carrier frequencies in the range of $[7998.95, 8001.05]$ MHz.