ECE678 Radar Engineering | Mark R. Bell
Fall 2022 | MSEE 336

Homework Assignment #1
Revision 1
Due Friday September 9, 2022

Reading Assignment: Draft Text Handout, Chapter 1 and Chapter 2.

1. (*Adapted from Levanon: 1.2*) If a radar transmits a narrowband signal at carrier frequency f_T that is reflected by a target moving with radial velocity v directed at the radar, the carrier frequency of the received signal is given by

$$f_R = \left(\frac{1 + v/c}{1 - v/c}\right) f_T.$$

If $v = 300\,\mathrm{m/s}$, compare the Doppler frequency obtained using this formula and the simple approximation

$$f_D \approx \frac{2v}{\lambda} = \frac{2vf_T}{c}.$$

2. (*Levanon: 1.4*) A radar with antenna gain G_1 is illuminating at a target antenna whose gain is G_2. A receiver is connected at the target antenna. Suppose half the power received by the target antenna is forwarded to the receiver and the other half is reflected back to the radar.
   (a) Find an expression for the ratio between the power received by the receiver and the power received by the radar.
   (b) What is the ratio, in decibels, when $G_1 = G_2 = 100$ and $R/\lambda = 10^4$?

3. (*Levanon: 1.5*) A police radar is designed to receive the return from a car having radar cross section σ up to a distance of $R_M = 50\,\mathrm{m}$. The car is equipped with a radar detector having an antenna with effective area $k\sigma$, where $k = 0.001$. The police radar has an antenna with gain $G = 100$ and operates at a wavelength of $\lambda = 2\,\mathrm{cm}$. Assume that the radar receiver and the radar detector receiver have the same sensitivity (i.e, they require the same input power to detect a signal.) At what distance will the radar detector provide a warning?

4. A space probe at a distance of 10^6 km has a parabolic reflector antenna with a diameter of 2 meters (assume 100 % aperture efficiency) and a 50 W transmitter operating at 3 GHz. The ground receiver has a 64 meter (diameter) antenna with an aperture efficiency of 0.6. Assume that the two antennas are pointing at each other. What is the received power at the ground station?

5. Find the antenna gain pattern $G(\theta, \phi)$ of a uniformly illuminated square aperture with sides of length W for an illuminating wavelength λ at small angles θ and ϕ.

6. Find the antenna gain pattern $G(\theta, \phi)$ of a uniformly illuminated circular aperture with diameter D for an illuminating wavelength λ at small angles θ and ϕ.

7. Assume that the far field of an aperture of diameter D begins at the range such that the distance from a point along boresight to the edge of the aperture is $\lambda/8$ further than the distance from the point to the center of the aperture. Find the distance to the beginning of the far field for the following diameters and wavelengths:
   (a) $D = 3\,\mathrm{m}$ and $\lambda = 7.5\,\mathrm{cm}$;
   (b) $D = 100\,\mathrm{m}$ and $\lambda = 7.5\,\mathrm{cm}$;
   (c) $D = 30\,\mathrm{m}$ and $\lambda = 1\,\mathrm{cm}$;
   (d) $D = 3\,\mathrm{m}$ and $\lambda = 6000$ Angstroms.