Radio Astronomy and Interferometry 2015
Demonstrations, Set 1

1.a) Calculate the flux density, in jansky (Jy), of a small angular size microwave source with an output of 600 W at a distance of 10 m if the power is isotropically radiated and is uniformly emitted over a bandwidth of 1 MHz.
1.b) Calculate the flux density if the same source was located at the distance of the Moon.

2. Suppose the extraterrestrials in the next planetary system, assumed to be at a distance of 1 pc, use a 200 MW transmitter to broadcast information at a wavelength of 21 cm over a bandwidth of 10 kHz (emission is assumed to be uniform over this band).
a) What would be the flux density we receive, in Jy?
b) How many watts would be collected with an antenna with an area of 7800 m^2?

3. An anti-collision radar is being designed for cars, operating at 79 GHz. The bandwidth is proposed to be 100 MHz, and at the distance of 3 m the power per area is 10^{-9} W m^{-2} (power level assumed to be uniform over the whole bandwidth).
a) What is the flux density of the radar at 1 km distance?
b) A typical radio telescope can measure fluxes down to the mJy level. At what distance will such radars disturb such astronomy measurements?

4. A cable has an optical depth $\tau = 0.1$ and a temperature of 300 K. A signal of 1 K peak temperature is connected to the input of this cable. Use the radiation transfer equation and calculate the temperature of the output of the cable. (The 1 K signal can be taken as the source and the cable is absorbing and emitting on the way.)

5. Suppose you want to detect a continuum signal of peak temperature of 10^{-3} K with a total power receiver with a system noise T_{sys} = 100 K and a bandwidth of 500 MHz. How long must you integrate to obtain a 3σ detection?

6.a) The MERLIN interferometer system has a maximum baseline length of 227 km. At an observing frequency of 5 GHz, what is the angular resolution?
6.b) Suppose that the RMS noise after long integration is 50 μJy. Use the Rayleigh-Jeans relation to obtain the RMS noise in terms of main beam brightness temperature. If a thermal source has at most a peak temperature of 5×10^5 K, can we detect its thermal emission?

7. You get from your friends a radio receiver operating at 12 GHz. You want to observe radio emission from the Sun, and you want to be sure of observing all activity from the whole disk. What is the size of the antenna you need? What are the basic requirements for the antenna?