Learning Objective 1.1: I can define noise figure and explain how each stage of a receiver chain, the first above all, sets the system's noise performance.

Learning Objective 1.2: I can compute a link budget for a specified geometry, transmitter, and antenna configuration, and compare it with the signal an SDR shows.

Show your work. Write a **Documentation** line at the end (**None** if you did not collaborate).

1. **Decibels and the ISM bands.** A small 915 MHz telemetry radio puts out 100 mW. It connects to a 9 dBi antenna through a cable and connectors with 2 dB of loss.

   (a) Express 5 W and 0.1 μW in dBm.

   5 W = ____

   0.1 μW = ____

   (b) Find the radio's EIRP in dBm and in milliwatts.

   EIRP = ____

   EIRP = ____

   (c) Which of the common ISM bands, 915 MHz, 2.4 GHz, and 5.8 GHz, can the course PlutoSDR receive and transmit in? Would a Pluto as shipped, 325 MHz to 3.8 GHz, cover the same ones?

   (d) Explain in one or two sentences why Wi-Fi, Bluetooth, and most hobby drones all operate in the same few bands.

2. **Free-space path loss.** A 915 MHz radio talks to a ground station 10 km away. Both antennas have 6 dBi of gain, and the transmitter delivers 1 W to its antenna.

   (a) Find the free-space path loss at 915 MHz and 10 km.

   L_p =

   (b) Find the received power in dBm.

   P_r =

   (c) The same system moves to 2.45 GHz with the same antenna gains and twice the distance. Find the new path loss using the rules of thumb, then check it with the full expression.

   L_p =

   (d) Path loss is not absorption, yet it grows with frequency. Explain why in one or two sentences.

3. **The noise floor.** A PlutoSDR with a 6 dB noise figure receives a broadcast FM station. One FM channel occupies about 200 kHz.

   (a) Find the receiver's noise floor in one 200 kHz channel.

   N =

   (b) The station arrives at -80 dBm. Find the SNR in the channel.

   SNR =

   (c) A student leaves the receiver filter open to the full 2.4 MHz sample rate and measures the station's power against all of that noise. Why does the wide filter show a lower SNR, and which SNR does the FM demodulator experience?

4. **Where the LNA goes.** A ground station has a 2 dB cable run, an LNA with NF 0.8 dB and 18 dB of gain, and an SDR with NF 7 dB. The system noise figure of each arrangement is:

antenna → cable → LNA → SDR	3.0 dB
antenna → LNA → cable → SDR	1.2 dB
antenna → cable → SDR (no LNA)	9.0 dB

   (a) Where should the LNA go, and what would you tell someone who wants to mount it next to the SDR to keep it out of the weather?

   (b) Explain why the cable's loss matters so much more in front of the LNA than behind it.

   (c) Without the LNA the noise figure is 9.0 dB, the cable's 2 dB plus the SDR's 7 dB. You add the LNA at the antenna. What happens on the SDR's display to the noise floor, to a weak signal near it, and to the SNR?

5. **A GPS link budget.** A GPS satellite transmits the L1 signal at 1575.42 MHz with an EIRP of 27 dBW. A receiver on the ground sees the satellite directly overhead at 20,200 km through a 0 dBi antenna. Polarization and atmospheric losses total 2 dB. The receiver has a 2 dB noise figure and a 2 MHz bandwidth.

   (a) Find the free-space path loss and the received power in dBm.

   L_p =

   P_r =

   (b) Find the noise floor and the SNR at the receiver.

   N =

   SNR =

   (c) The signal arrives below the noise floor, yet GPS works everywhere. Explain in one or two sentences how.

   (d) A car's GPS antenna sits on the roof with 5 m of cable to the dashboard receiver. Where should the LNA go, and why? Use your answer to (b) to explain what is at stake.

6. **Reading SNR on an SDR.** A GNU Radio frequency sink shows an unmodulated carrier from a signal generator, received by a PlutoSDR running at $f_s = 2.4$ MHz with an FFT size of 2048. The carrier's peak reads -32 dBFS and the noise floor beside it reads -78 dBFS.

   (a) Find the SNR the display shows, and the width of one FFT bin.

   SNR = ____

   bin = ____

   (b) The display reads dBFS, not dBm. Why can you still read an SNR off it?

   (c) You change the FFT size from 2048 to 8192. What happens to the noise floor, to the carrier's peak, and to the SNR the display shows, and why?

Documentation: _____