Problem Set 12: Due on Tuesday, 27-Apr-99 at begin of lecture.
                        Discussion on Wednesday, 28-Apr-99 at 12 – 1 PM in 347 LeConte.
                        Office hours: Mondays, 3 – 4 PM in 420 LeConte

1. A detector with a capacitance of 10 pF is used with a JFET preamplifier. The detector
   and FET are cooled, so the detector and gate current noise are negligible. Assume that
   the electronic noise is due only to the input JFET. The pulse shaper has a peaking time
   of 1 μs (assume $F_i = F_v = 1$).

   a) The input JFET has a transconductance of 5 mS (mA/V) and an input capacitance
      of 5 pF. What is the equivalent noise charge (expressed in electrons)?

   b) The input transistor is replaced by another device, also with 5 mS transconductance,
      but with an input capacitance of 10 pF. What is the equivalent noise charge?

   c) The JFET used in b) provides capacitive matching, yet the noise charge is higher
      than in a). Why?

2. Two identical amplifiers with a voltage gain of 10 are cascaded (connected in series)
   to provide high gain. Both amplifiers have an input referred noise of 10 μV, integrated
   over their full bandwidth. What is the input referred noise of the amplifier cascade?

3. A bipolar transistor amplifier is connected to a detector with 10 pF capacitance. Again,
   the detector is cooled, so its current noise is negligible. The transistor has a current
   gain of 150, constant over the current range of interest, and its input capacitance is
   1 pF. The shaper uses simple CR-RC filtering with $\tau_i = \tau_d$.

   a) What is the minimum obtainable noise charge (expressed in electrons)?

   b) At what current must the transistor be operated to obtain the minimum noise at a
      peaking time of 1 μs?

   c) At a peaking time of 10 ns, what is the optimum noise and the required operating
      current?

   d) If you accept a 10% higher noise level, what is the minimum operating current at
      10 ns shaping time?

   e) The system is exposed to a hadron beam. Radiation damage in the transistor reduces
      the DC current gain to 50. At 10 ns peaking time and the current determined in d),
      what is the noise?

   f) What are the optimum operating current after irradiation and the associated noise?