The answers to the problems are given. You must show how you get the answers for credit. Please follow the homework guidelines described at

http://users.ece.gatech.edu/~mleach/ece3050/hwguide.html

1. Let \( v_n(t) \) be a random voltage that has a normal or Gaussian probability density function with a mean value of zero and a standard deviation or mean-square of \( v_{rms} \). In a 24 h period, the total time that the waveform exceeds a value \( v_1 \) can be estimated as 24 h multiplied by the probability that \( |v_n(t)| > v_1 \). Calculate the time that (a) \( |v_n(t)| > 3v_{rms} \) [about 4 min], (b) \( |v_n(t)| > 4v_{rms} \) [about 5 s], and (c) \( |v_n(t)| > 6v_{rms} \) [about 0.2 ms].

2. Two resistors \( R_1 \) and \( R_2 \) are connected in parallel. The two resistors are in thermal equilibrium.

   (a) Suppose that only \( R_1 \) generates thermal noise and \( R_2 \) is noiseless, show that the average thermal noise power in watts delivered by \( R_1 \) to \( R_2 \) in the band \( \Delta f \) is given by

   \[
P_{12} = \frac{4kTR_1R_2\Delta f}{(R_1 + R_2)^2}
   \]

   (b) Suppose that only \( R_2 \) generates thermal noise and \( R_1 \) is noiseless, show that the average thermal noise power \( P_{21} \) delivered by \( R_2 \) to \( R_1 \) in the band \( \Delta f \) is given by the same expression obtained above.

   (c) Note that \( P_{12} = P_{21} \). If the two answers were not the same, could the two resistors be in thermal equilibrium? How would the temperatures of the individual resistors vary with time if \( P_{12} > P_{21} \)?

3. Calculate the thermal spot noise voltage in \( \text{V}/\sqrt{\text{Hz}} \) (volts per root hertz) at the standard temperature across the terminals of the circuit \( [v_{rms} = 8.72 \text{nV}/\sqrt{\text{Hz}}] \)

   ![Circuit Diagram]

4. Calculate the spot noise voltage at the output of the circuit at the frequency \( f = 1.5 \text{kHz} \). Assume \( T = T_0 = 290 \text{K} \). \( [9.83 \text{nV}/\sqrt{\text{Hz}}] \)

   ![Circuit Diagram]
5. A 1 MΩ resistor has a dc voltage across it of 4 V. At the frequency \( f = 100 \text{ Hz} \), the spot noise voltage across the resistor is \( v_n / \sqrt{\Delta f} = 400 \text{ nV} / \sqrt{\text{Hz}} \).

(a) Show the flicker noise coefficient is \( K_f = 9 \times 10^{-13} \).
(b) Show that the noise index is \( NI = 3.17 \text{ dB} \).
(c) The mean-square short-circuit noise current generated by the resistor is given by

\[
i_n^2 = \frac{4kT \Delta f}{R} + \frac{K_f I_{DC} \Delta f}{f}
\]

Show that the flicker noise corner frequency is \( f_{flk} = 900 \text{ Hz} \).

6. A 100 mH lossy inductor has a measured impedance magnitude of 8 kΩ at the frequency \( f = 10 \text{ kHz} \). Show that the open-circuit thermal spot noise voltage generated by the inductor at 10 kHz is \( v_t / \sqrt{\Delta f} = 8.9 \text{ nV} / \sqrt{\text{Hz}} \). Note that \( |Z|^2 = R^2 + (\omega L)^2 \) for the inductor.

7. If the diode generates only shot noise and the resistor generates only thermal noise, solve for the ac rms noise output voltage over the band from 1 kHz to 3.5 kHz. The diode is modeled as a shot noise current source in parallel with the diode small-signal resistance given by \( r_d = \frac{\eta V_T}{I_D} \), where \( \eta \) is the emission coefficient or ideality factor and \( I_D \) is the dc current in the diode. Assume \( \eta = 2 \) and \( V_T = 25 \text{ mV} \). \([v_{rms} = 23.9 \text{ nV}]\)