1. For Problem 1 of Assignment 2, show that $F = 19.78$ and $NF = 12.96$ dB with $R_1$ and $C_1$ in the circuit. Show that $F = 6$ and $NF = 7.782$ dB if $R_1$ is replaced by an open circuit and $C_1$ is replaced by a short circuit.

2. The noise figure of an op amp is $NF = 5$ dB with a source resistance of $R_s = 10\, k\Omega$.
   
   (a) Show that $v_{ni}/\sqrt{\Delta f} = 22.49\, nV/\sqrt{\text{Hz}}$.
   
   (b) Show that the noise temperature is $T_n = 627\, K$.
   
   (c) Show that a resistor of value $21.6\, k\Omega$ at the op amp input would generate the same noise as the op amp.

3. For Problem 2 of Assignment 2, show that $F = 67.24$ and $NF = 18.28$ dB.

4. Given $G_n$, $F_{min}$, and $Z_{opt} = R_{opt} + jX_{opt}$ for an amplifier, show that

   $$i_n^2 = 4kTG_n\Delta f$$
   $$\gamma_i = \frac{-\text{sgn}(X_{opt})}{\sqrt{1 + (R_{opt}/X_{opt})^2}}$$
   $$v_n^2 = \left(\frac{X_{opt}}{\gamma_i}\right)^2 i_n^2$$
   $$\gamma_r = \frac{2kT_0\Delta f}{\sqrt{v_n^2}\sqrt{i_n^2}}(F_{min} - 1) - \sqrt{1 - \gamma_i^2}$$

   where $\text{sgn}(X_{opt}) = X_{opt}/|X_{opt}|$.

5. An amplifier has an input resistance of $150\, \Omega$. Its noise parameters are $v_n/\sqrt{\Delta f} = 2\, nV/\sqrt{\text{Hz}}$, $i_n/\sqrt{\Delta f} = 10\, pA/\sqrt{\text{Hz}}$, and $\gamma = 0$. It is driven from a source having an output resistance of $75\, \Omega$.
   
   (a) Show that $v_{ni}/\sqrt{\Delta f} = 2.401\, nV/\sqrt{\text{Hz}}$.
   
   (b) Show that $F = 4.802$ and $NF = 6.814$ dB.
   
   (c) A resistor $R_1$ is added in series with the source to make the source impedance seen by the amplifier equal to $Z_{opt}$. Show that $R_1 = 125\, \Omega$. If the resistor is considered to be part of the source, not the amplifier, show that $F = 3.5$ and $NF = 5.441$ dB.
   
   (d) The result for $F$ above illustrates the noise factor fallacy. For a proper noise analysis, $R_1$ must be considered to be part of the amplifier, not the source. Show that the correct values are $F = 9.333$ and $NF = 9.7$ dB.
   
   (e) Show that $R_1$ reduces the $SNR$ by $2.886$ dB.

6. The amplifier in problem 5 is driven from a source having an output resistance $R_s = 1\, k\Omega$.
   
   (a) Show that $v_{ni}/\sqrt{\Delta f} = 10.95\, nV$.
   
   (b) Show that $F = 7.5$ and $NF = 8.751$ dB.
(c) A resistor $R_2$ is added in parallel with the source to make the source impedance seen by the amplifier equal to $Z_{opt}$. Show that $R_2 = 250 \Omega$. If the resistor is considered to be part of the source, not the amplifier, show that $F = 3.5$ and $NF = 5.441 \text{dB}$.

(d) The result for $F$ above illustrates the noise factor fallacy. For a proper noise analysis, the parallel resistor must be considered to be part of the amplifier, not the source. Show that the correct values are $F = 17.5$ and $NF = 12.43 \text{dB}$.

(e) Show that $R_2$ reduces the $SNR$ by 3.68 dB.

7. An amplifier has a voltage gain of 200 and an input resistance of 5 k$\Omega$. With a resistor of value 5 k$\Omega$ connected in parallel with its input, the output noise measures 447 $\mu$V over a noise bandwidth of 100 kHz. The 5 k$\Omega$ resistor is removed and a white noise source is connected through an attenuator to the input of the amplifier. The attenuator consists of a series 30 k$\Omega$ resistor and a shunt 6 k$\Omega$ resistor. The output resistance of the attenuator is 5 k$\Omega$. The source voltage over a noise bandwidth of 100 kHz has the value $v_n = 53.7 \mu$V. With the source activated, show that the noise output voltage from the amplifier increases to 1 mV. Use this information to show that $F = 2.5$ and $NF = 3.98 \text{dB}$.

8. An amplifier is connected to a source with an output resistance $R_s$ through a lossy transmission line having a characteristic impedance $Z_c = R_s$. If the loss in the cable is $k \text{dB}$, show that the noise figure is increased by $k \text{dB}$.