Problem 1.  (20 points)
Consider the circuit shown below. Assume the NPN transistor has a $\beta$ of 250 and an infinite early voltage. Use short-circuit time constant analysis to determine the lower corner frequency, $f_L$, of the amplifier. I solved the DC problem and determined that $I_C$ is 2 mA.

(a) Determine the $r_\pi$ of the transistor.

(b) Determine the equivalent time constant associated with capacitor, $C_1$?

(c) Determine the equivalent time constant associated with capacitor, $C_2$?

(d) What is $f_L$?
Problem 2. (20 points)

Consider the circuit shown below. Assume the NPN transistor has a $\beta$ of 250 and an infinite Early voltage. Use open-circuit time-constant analysis and Miller’s Theorem to determine the upper corner frequency, $f_H$, of the amplifier. The capacitor $C_3$ is much larger than the transistor parasitic capacitances, $C_\pi$ and $C_\mu$, and therefore these may be ignored. I solved the DC problem and determined that $I_C$ is 2 mA.

(a) What is the midband-frequency gain of the amplifier (from base node to collector node)?

(b) What is value of the Miller capacitance from the base of the transistor to ground?

(c) Compute the relevant time constants.

(d) What is $f_H$?
Problem 3.  (20 points)

Consider the closed-loop amplifier shown below.

(a) What type of negative feedback is being utilized? (series-series, series-shunt, shunt-shunt, shunt-series)?

(b) Draw the feedback network and determine the feedback factor, B.

(c) What is the closed-loop gain, $A_f$, approximately?
Problem 4. (20 points)

Consider a negative feedback system. The typical open-loop gain of the op amp used in the design is 35,000 V/V but this open-loop gain is accurate only to 20%. A closed-loop gain of 25 V/V is desired.

(a) What is the minimum value of GBW required by this application so that the closed-loop bandwidth of the amplifier is 10 MHz?

(b) What value of B is needed so that the closed-loop gain will be exactly 25 when the typical value of A is used?

(c) How much error (approximately) will there be in the closed-loop gain due to the error in the open-loop gain?

(d) If the input impedance of the open-loop system is 5 MΩ, what is the input impedance of the resulting closed-loop system?
Problem 5. (10 points)

Answer the questions concerning the classic block diagram which is used to describe negative feedback systems. Assume $x_s$ is 1 mA, $x_o$ is 500 mV, and $x_i$ is 1 $\mu$A.

(a) What is A?

(b) What kind of feedback amplifier is this? (voltage, current, transresistance, transconductance)?

(c) What is the feedback factor, B?

(d) What is the loop gain?
Problem 6.  (10 points) *** GRADUATE STUDENTS ***

An engineer wants to implement a negative feedback system using a series-shunt feedback topology. The closed-loop gain should be 0.5.

(a) What must the feedback factor, B, be approximately?

(b) Draw a circuit that can be used to implement the feedback factor i.e. a circuit that can be used to achieve the value of B from part (a). Hint: An active rather than a passive circuit is needed.

(c) Draw the complete negative feedback circuit. Hint: You should have two op amps in your circuit!