1. **Gain Analysis**

Connect $v_C$ and $v_D$ to the ground in the circuit in Fig. 1 and answer the following questions:

(a) (3 points) Calculate the gains: $v_i$ to $v_A$, $v_A$ to $v_B$, $v_B$ to $v_o$.

(b) (1 point) Calculate the gain: $v_i$ to $v_o$.

(c) (4 points) Calculate the gain $v_s$ to $v_o$ if a circuit with Thevenin voltage $v_s$ and equivalent resistance $2R_1/3$ is connected to the input $v_i$.

(d) (1 point) If a circuit is to be connected to $v_i$ as in part (c), show how you could add an opAmp circuit before connecting the circuit to $v_i$ to make the gain from $v_s$ to $v_o$ equal to the gain from $v_i$ to $v_o$.

2. **Voltage Offset**

Let $v_C = v_D = 1V$ and answer the following questions regarding the opAmp circuit in Fig. 1:

(a) (3 points) Show that $v_A = 11 - 10v_i$, $v_B = 100v_i - 99$, $v_o = 50v_i - 49.5$.

(b) (3 points) Let the signal $v_i = 1 + v_r$ in which $-0.01V \leq v_r \leq 0.01V$. Calculate the corresponding range for the signal $v_o$ and the the gain from $v_r$ to $v_o$.

(c) (2 points) Calculate the largest possible value of $-v_{CC}$ and the smallest possible value of $+v_{CC}$ so that the voltages $v_A$ and $v_B$ do not saturate for a signal $v_i = 1 + v_r$ as in part (b).

(d) (1 point) Let $+v_{CC} = 2V$ and $-v_{CC} = 0V$ and design an additional circuit with access only to theses voltages that when connected to the circuit in Fig. 1 is such that $v_C = v_D = 1V$.

3. **OpAmp Design**

Design an opAmp circuit that implements the following operations $v_o = 2(v_1 - v_2) + v_3$

(a) (3 points) Using any number of opAmps.  

(b) (3 points) Using at most two opAmps.  

(c) (3 points) Using at most one opAmp.  

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Figure 1: Circuit for Questions 1 and 2

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Not necessary if part (a) has two opAmps or less
Not necessary if part (b) has one opAmp