

Q2

b) Find v_1 using voltage divider rule given that the $16\ \Omega$ and $24\ \Omega$ resistors are in series because $I_1 = 0$. Next, v_2 can be found as a consequence of the property that there is no voltage difference between the input terminals of the op amp.

c) I_4 is simply the ratio of v_2 dropped over the $8\ \Omega$ and $12\ \Omega$ resistors in series.

d) I_3 can be found by applying KCL at node v_2 given that I_2 and I_4 are known.

Q3

b) Since $I_1 = 0$, there is no voltage drop across the $10\ \text{k}\Omega$ resistor $\Rightarrow v^- = 0$. Next, v^+ can be found as a consequence of the property that there is no voltage difference between the input terminals of the op amp.

c) Note that $I_S = I_F$ because $I_2 = 0$. And I_S is simply v_s dropped over the $5\ \text{k}\Omega$ resistor since $v^- = 0$.

Q4

a) V_1 can be found by applying nodal voltage analysis at node V_1 , bearing in mind that $v^- = 0$. Alternatively, you can treat the two $4\ \text{k}\Omega$ resistors to be parallel and use voltage divider rule with the $2\ \text{k}\Omega$ in series.

b) Note that $I_1 = I_3$ since $I_2 = 0$. I_1 can be found by considering the voltage drop across the $4\ \text{k}\Omega$ resistor.

c) To find i_o , apply KCL at the output of the op amp. You will need to know the current in the $2\ \text{k}\Omega$ load at the output ($0.46875\ \text{mA}$ from ground to the op amp output).

d) Current supplied by the source is current in the $2\ \text{k}\Omega$ resistor in series with the source. The current in the $2\ \text{k}\Omega$ resistor can be found by considering the voltage drop across the $2\ \text{k}\Omega$ resistor. The input resistance is simply the ratio of the source voltage over the source current.

Q5

b) I_2 remains zero even with a source because of the infinite input resistance of the op amp. By extension, $I_1 = I_3$. I_1 can be found by considering the voltage across the $4\ \text{k}\Omega$ resistor as long as v^- is known.

c) Finally v_o is found by considering the voltage drop across the $10\ \text{k}\Omega$ which can be found when I_3 is known. Note that this voltage is dropped from v^- , so v^- needs to be considered when working out the value of v_o .

Q6

b) Note there is no voltage difference across the $20\ \text{k}\Omega$ resistor so v^+ takes the value of v_s .

c) v_o can be found directly from v^- using voltage divider rule since $I_2 = 0$.

d) I_3 in this case is just equal to the current in the $10\ \text{k}\Omega$ resistors.

e) Adding the $5\ \text{k}\Omega$ does not change v_o , but now I_3 must increase to provide the current in the $5\ \text{k}\Omega$ resistor. Work out the current in the $5\ \text{k}\Omega$ and then apply KCL at the op amp output node.

f) There is no current supplied by the source. So what is the ratio of source voltage and source current?

Q7

The $10\ \text{k}\Omega$ and $90\ \text{k}\Omega$ resistors are in series because $I_1 = 0$, allowing us to use voltage divider rule to find v^+ . I_3 can be found by considering the voltage across the $50\ \text{k}\Omega$ resistor. Note that the $100\ \text{k}\Omega$ and $50\ \text{k}\Omega$ resistor are in series. This allows us to apply voltage divider rule to find v_o . To find i_o , apply KCL at the output of the op amp. You will need to know the current through the $10\ \text{k}\Omega$ resistor at the output.

Q8

- b) The source currents can all be found by considering the voltage drop across the respective resistors with the knowledge that the $v^- = 0$.
- c) I_4 is the sum of all source currents because there is no input current to the op amp.
- d) v_o can be directly found by considering the voltage drop across the $30\text{ k}\Omega$ feedback resistor.

Q9

- b) Note that I_3 is a continuation of I_2 ($I_3 = -I_2$) because there is no input current to the op amp.
- c) V_o can be found by applying voltage divider rule given that the $10\text{ k}\Omega$ and $40\text{ k}\Omega$ resistors are in series. I_o can be found by applying KCL at the op amp output terminal after working out the current through the $40\text{ k}\Omega$ resistor.
- d) Note that since v^- is at ground, there will be no voltage drop across the added resistor. Adding this resistor therefore does not alter any of the existing branch currents or node voltages. Hence adding the resistor makes no difference to the circuit in this case.