

ECE101F19 Lecture 9 Oct.29, 2019
 OP-Amp circuits - Summing, difference
 PP189-194

HW #5 for Quiz 5 on Oct. 31

- 1) Prob 4.13
- 2) Prob 4.14
- 3) Prob 4.16
- 4) Prob 4.19
- 5) Prob 4.24
- 6) Prob 4.30
- 7) Prob 4.38
- 8) Prob 4.40
- 9) Prob 4.52

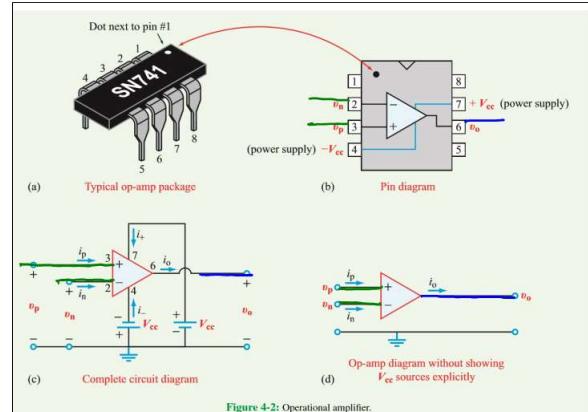
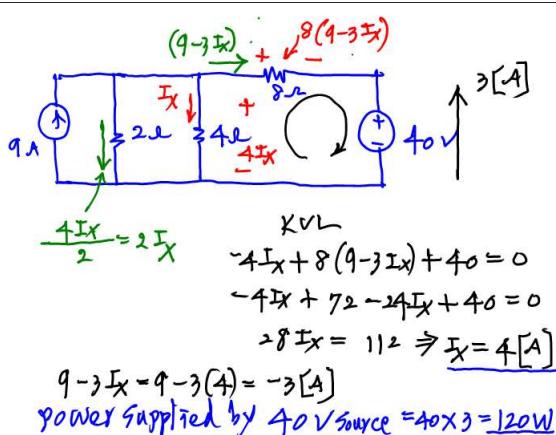
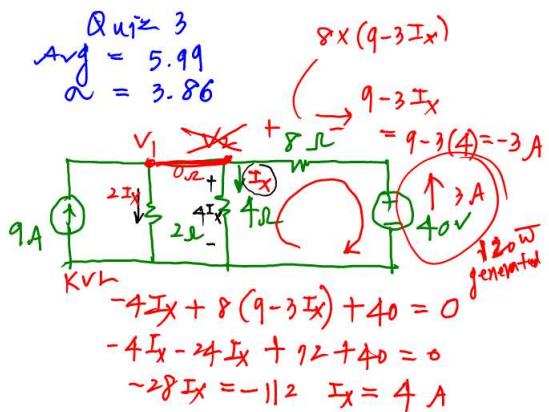


Figure 4-2: Operational amplifier.

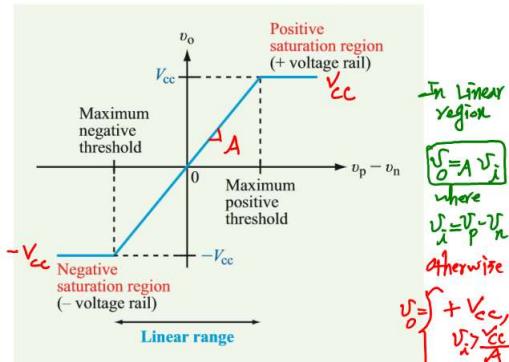


Figure 4-3: Op-amp transfer characteristics. The linear range extends between $v_o = -V_{cc}$ and $+V_{cc}$. The slope of the line is the op-amp gain A .

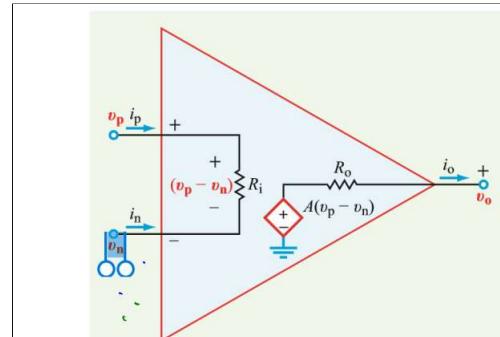


Figure 4-6: Equivalent circuit model for an op amp operating in the linear range ($v_o \leq |V_{cc}|$). Voltages v_p , v_n , and v_o are referenced to ground.

Table 4-1: Characteristics and typical ranges of op-amp parameters. The rightmost column represents the values assumed by the ideal op-amp model.

Op-Amp Characteristics	Parameter	Typical Range	Ideal Op Amp
• Linear input-output response	Open-loop gain A	10^4 to 10^8 (V/V)	∞
• High input resistance	Input resistance R_i	10^6 to 10^{13} Ω	$\infty \Omega$
• Low output resistance	Output resistance R_o	1 to 100Ω	0 Ω
• Very high gain	Supply voltage V_{cc}	5 to 24 V	As specified by manufacturer

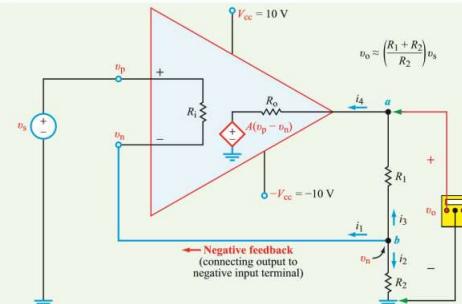
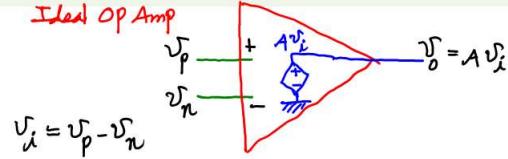
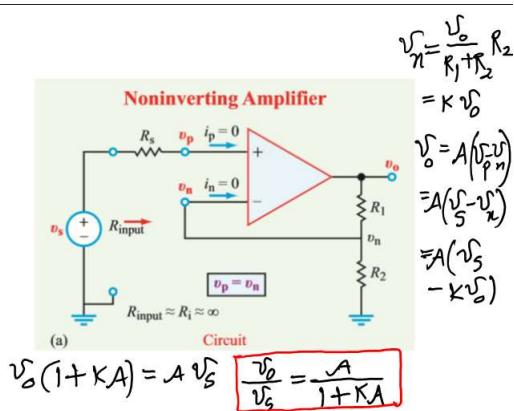


Figure 4-7: Noninverting amplifier circuit of Example 4-1.



$$G = \frac{v_o}{v_s} = \frac{A}{1 + KA} \rightarrow K = \frac{R_2}{R_1 + R_2}$$

when $A \rightarrow \infty$ (very large)

$$\frac{v_o}{v_s} = \frac{1}{K + \frac{1}{A}} \Big|_{K \rightarrow \infty} = \frac{1}{K} = \frac{R_1 + R_2}{R_2}$$

$$v_o = \left(\frac{R_1 + R_2}{R_2} \right) v_s$$

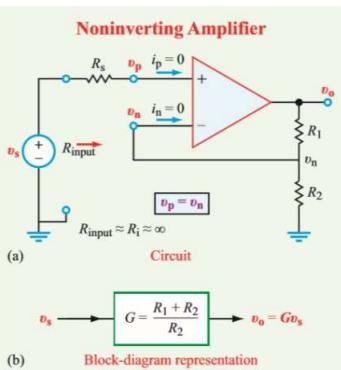


Figure 4-10: Noninverting amplifier circuit: (a) using ideal op-amp model and (b) equivalent block-diagram representation.

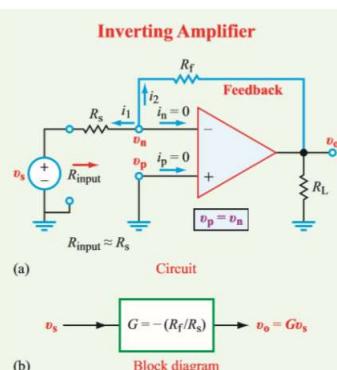
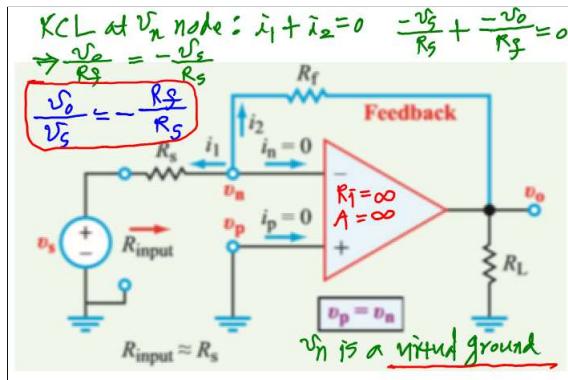


Figure 4-11: Inverting amplifier circuit and its block-diagram equivalent.



4.5 For the op-amp circuit shown in Fig. P4.5:

- Use the model given in Fig. 4-6 to develop an expression for the current gain $G_i = i_L/i_s$.
- Simplify the expression by applying the ideal op-amp model (taking $A \rightarrow \infty$, $R_i \rightarrow \infty$, and $R_o \rightarrow 0$).

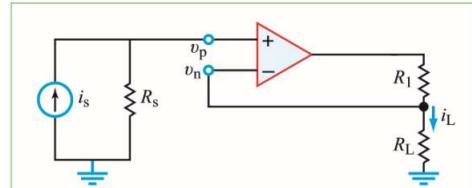
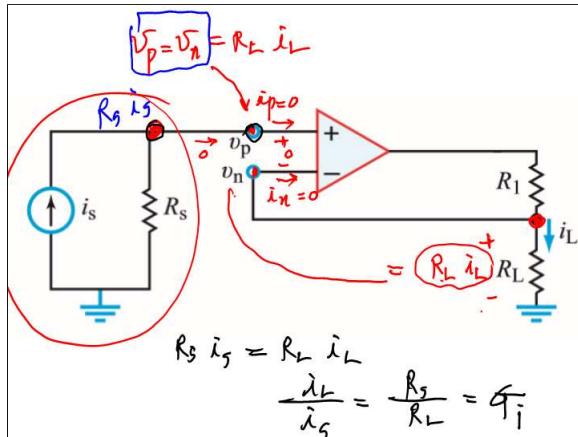


Figure P4.5: Circuit for Problem 4.5.



4.7 For the circuit in Fig. P4.7:

- Use the op-amp equivalent-circuit model to develop an expression for $G = v_o/v_s$.
- Simplify the expression by applying the ideal op-amp model parameters, namely $A \rightarrow \infty$, $R_i \rightarrow \infty$, and $R_o \rightarrow 0$.

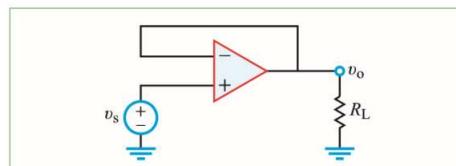
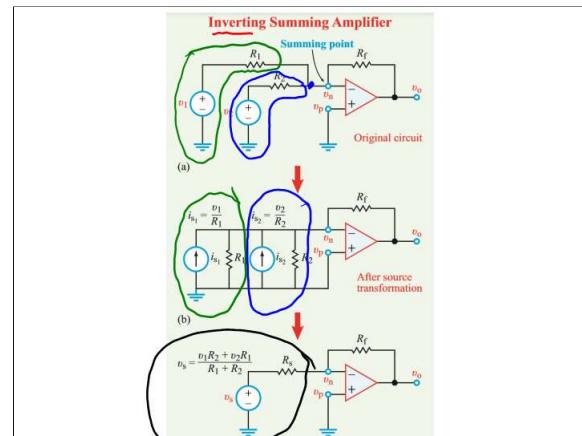
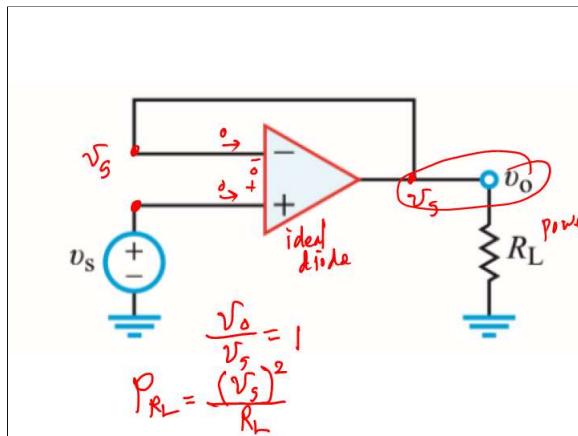
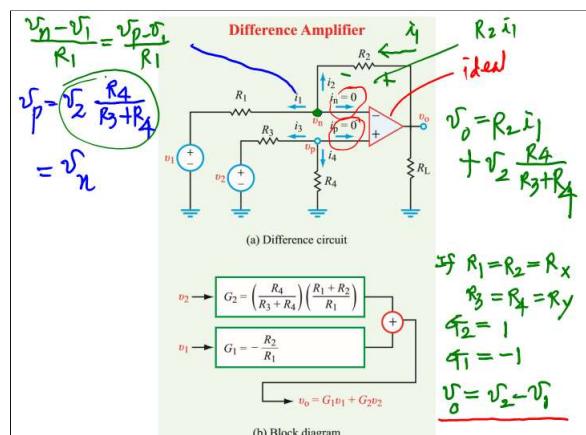
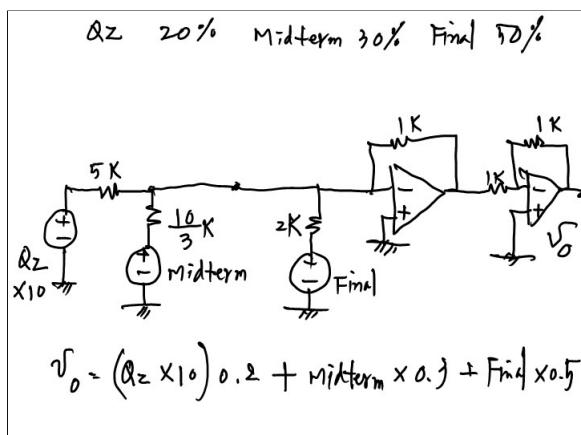
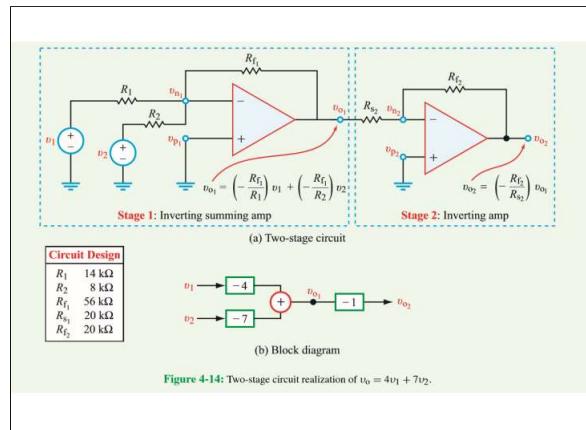
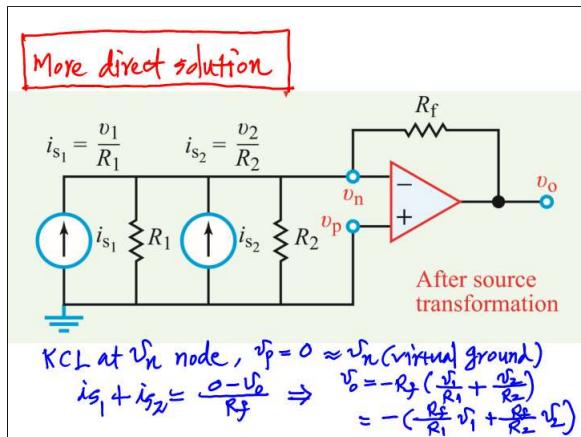
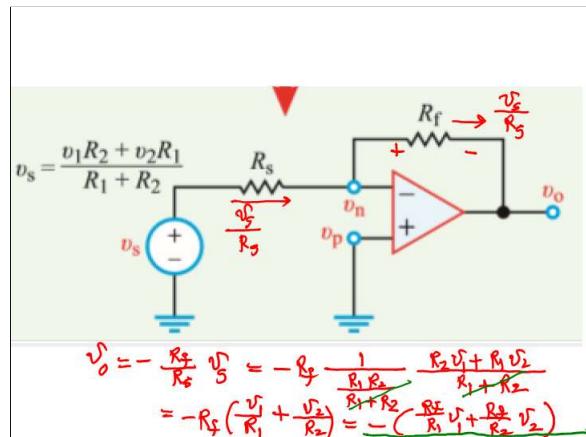
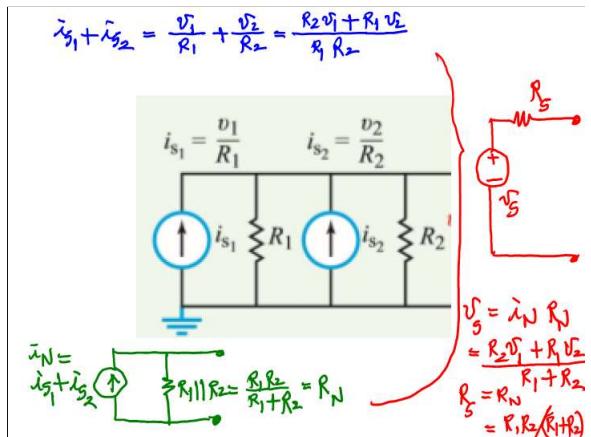
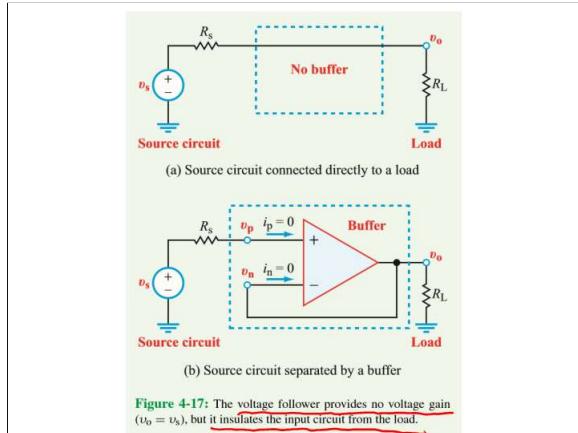


Figure P4.7: Circuit for Problem 4.7.







Exercise 4-7: Express v_o in terms of v_1 , v_2 , and v_3 for the circuit in Fig. E4.7.

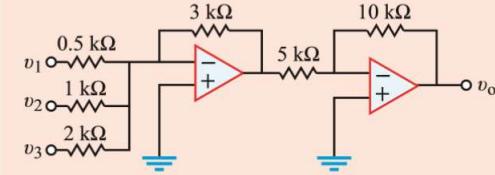


Figure E4.7

Answer: $v_o = 12v_1 + 6v_2 + 3v_3$. (See CAD)

