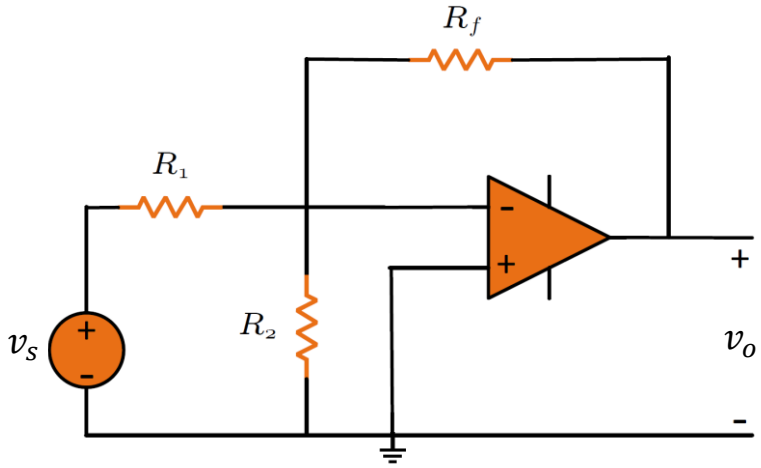
School of Electrical Engineering & Telecommunications

ELEC1111

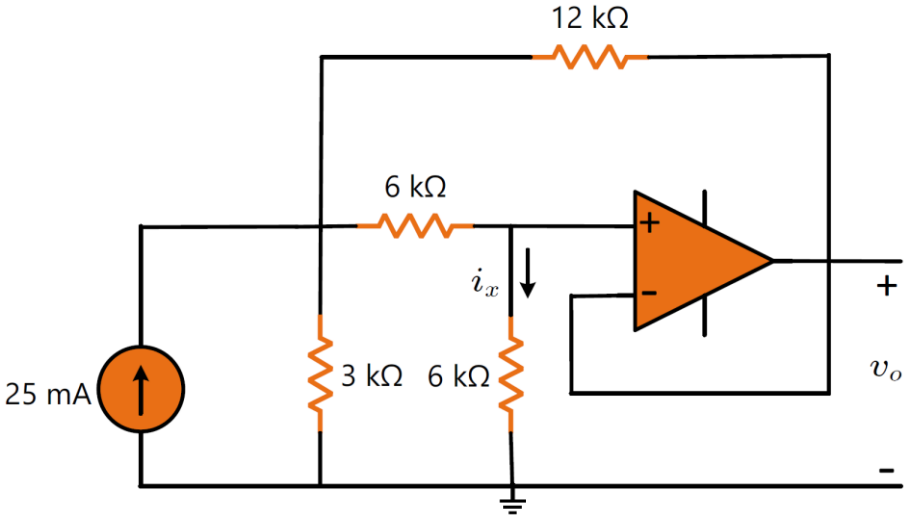
Topic 6: Operational Amplifiers

1. Find the voltage gain $\frac{v_o}{v_s}$ in the following operational amplifier circuit.



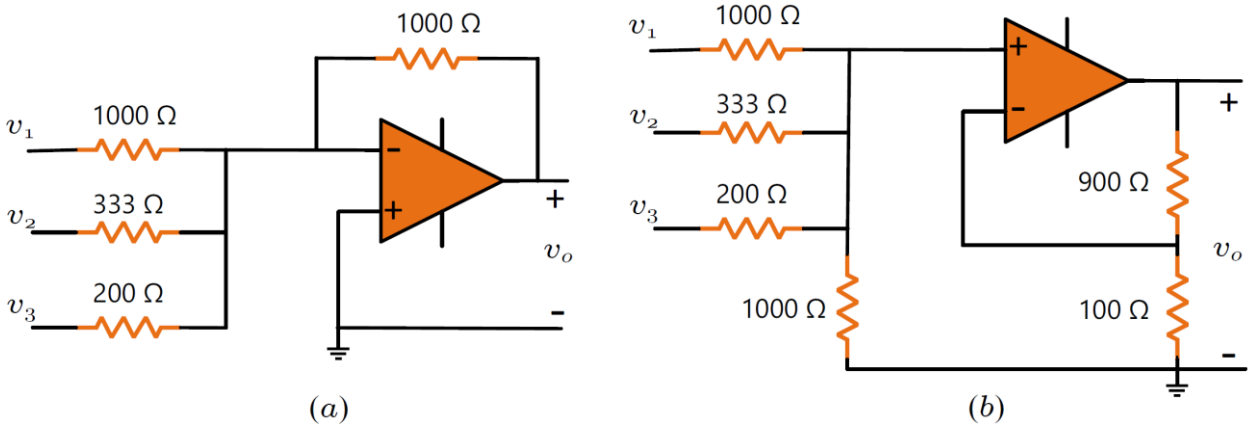
Answer: $\frac{v_o}{v_s} = -\frac{R_f}{R1}$

2. Find the current i_x in the following operational amplifier circuit.



Answer: $i_x = 4.545$ mA,

3. Calculate v_o in the following two Op Amp circuits in terms of three input voltages v_1, v_2, and v_3.



Answer:

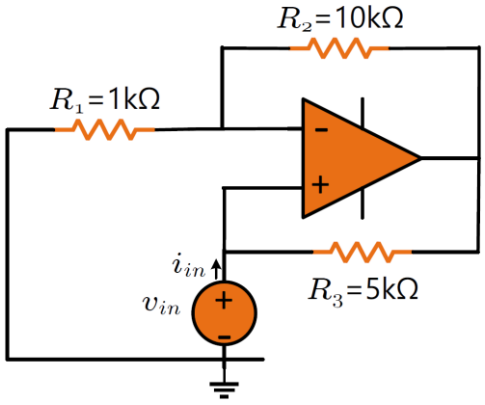
a) $v_o = -(v_1 + 3v_2 + 5v_3)$

b) $v_o = v_1 + 3v_2 + 5v_3$

4. In the following circuit,

a) Calculate the ratio $\frac{v_{in}}{i_{in}}$ in terms of R_1, R_2, and R_3, and then use the numerical values of resistances given in the circuit to determine the ratio. What does this ratio represent?

b) If $R_1 = R_2 = R$, determine the value of R_3 for the Op Amp circuit such that $\frac{v_{in}}{i_{in}} = -33\ \text{k}\Omega$

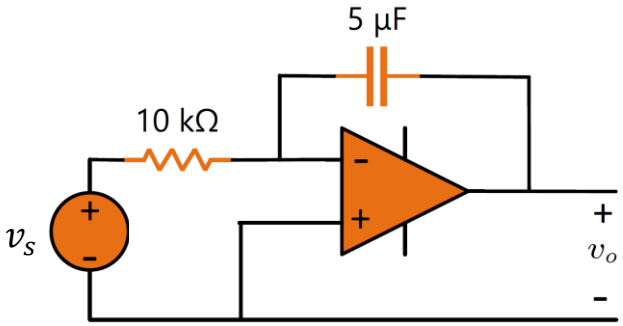


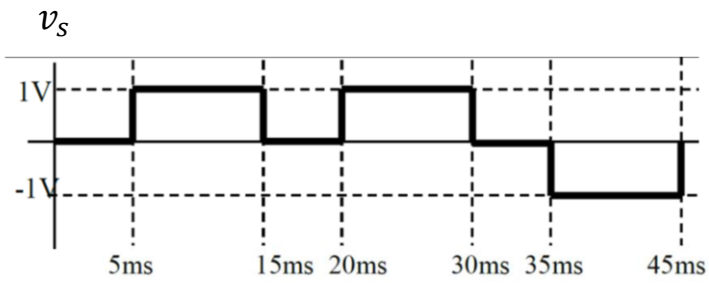
Answer:

a) $\frac{v_{in}}{i_{in}} = -\frac{R_1 R_3}{R_2}$

b) $R_3 = 33\ \text{k}\Omega$

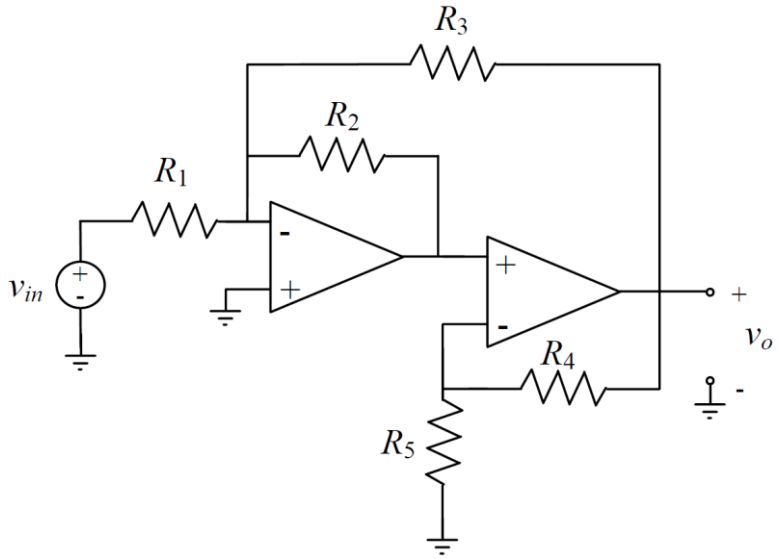
5. Calculate and draw the output voltage v_o in the following circuit for input voltage signal v_s given in the graph from $0 \leq t \leq 45$ ms .





Answer: $v_o(t) = -20\int_0^t v_s(\tau)d\tau$, You must complete the output graph sketch.

6. (**Final Exam – S1, 2014**) Consider the Op Amp circuit below with input v_{in} and output v_o.
   a) Derive an expression for the voltage gain $\frac{v_o}{v_{in}}$ in terms of the resistor values R_1, R_2, R_3, R_4, and R_5.
   b) If $R_1 = 1\ \text{k}\Omega$, $R_2 = 2\ \text{k}\Omega$, $R_3 = 3\ \text{k}\Omega$, and $R_5 = 4\ \text{k}\Omega$, determine the value of R_4 such that the voltage gain $\frac{v_o}{v_{in}} = -1.8$.



Answer:
a) $\frac{v_o}{v_{in}} = -\frac{R_2R_3(R_4+R_5)}{R_1R_3R_5+R_1R_2(R_4+R_5)}$
b) $R_4 = 5\ \text{k}\Omega$

7. Design a circuit with operational amplifiers that can generate the following output

$$v_o = 9v_1 - 6v_2$$

considering that the range of inputs are $1\ \mathrm{V} \leq v_1 \leq 2\ \mathrm{V}$ and $2\ \mathrm{V} \leq v_2 \leq 3\ \mathrm{V}$. The operational amplifiers have a supply voltage of $\pm 12\ \mathrm{V}$.

Hint: Consider the impact that the supply voltage of the operational amplifier has on the output of the device and how you can design around this limitation. This means that you have to break the design in two steps:
Step1: Design an Op Amp circuit for $v_{o1} = 3v_1 - 2v_2$ as first Op amp stage,
Step2: Cascade the Op Amp circuit in Step 1 to another Op Amp stage for $v_o = 3v_{o1}$.