**Indian Institute of Technology, Delhi**
**EEL 101: Fundamentals of Electrical Engineering**
**Tutorial 2, 29th January, 2008**

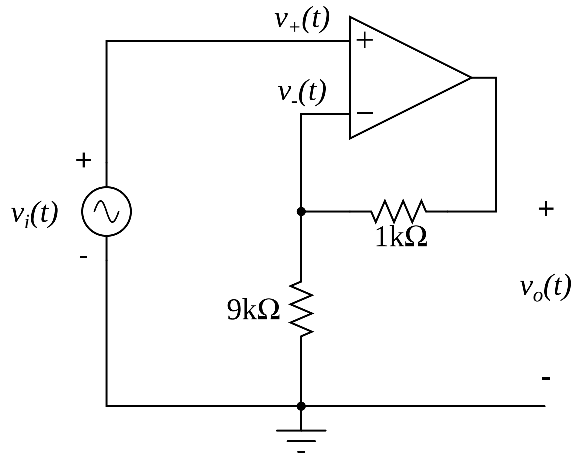



Figure 1:

1. Consider the op-amp circuit as shown in Fig. 1. Evaluate $v_o(t)$ as a function of $v_i(t)$ assuming that the op-amp is ideal (i.e, the op-amp can be replaced by the combination of a nullator and a norator.)

2. A real op-amp, however, does not behave like a voltage-controlled-voltage source with a very large gain. A realistic op-amp can be more accurately represented by the following:

$$v_o(t) = V_{DD} \tanh[A \times (v_+(t) - v_-(t))]$$

where $A$ is a large number, say, 10000, and $V_{DD}$ is the power supply voltage, say 5 Volts. $(\tanh(x) = (e^x - e^{-x})/(e^x + e^{-x}))$

   (a) For the circuit shown in Fig. 1, assume $v_i(t)$ is 0. Now plot $v_o(t)$ as a function of $v_+(t) - v_-(t)$, only using Kirchoff's equations.

   (b) On the same graph, plot $v_o(t)$ as a function of $v_+(t) - v_-(t)$ based on the op-amp equation presented above.

   (c) Based on the two plots, what is $v_o(t)$ when $v_i(t)$ is 0? What can you say about $v_o(t)$ when $v_i(t)$ is 0.1 Volts, 1 Volt, -0.1 Volts, -1 Volt?

   (d) What would you observe if the "+" and "-" terminals of the op-amp were to be interchanged? (What happens when you try balancing a ball at the peak of a hill?)

(e) Repeat all of the above steps, and make inferences for the circuit shown in Fig. 2.

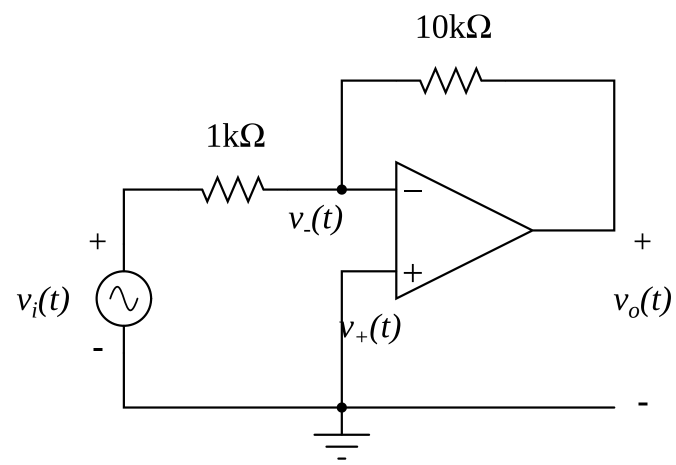
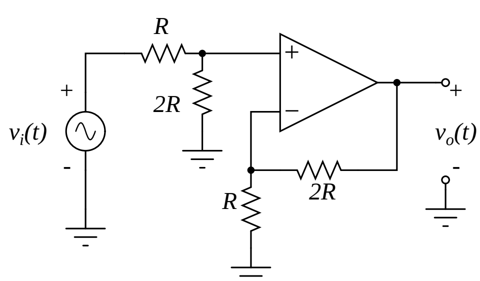
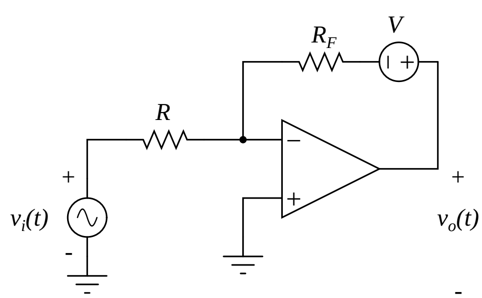



Figure 2:

3. Evaluate $v_o(t)$ as a function of $v_i(t)$ for the circuits shown in Figs. 3(a), and 3(b).




(a)




(b)