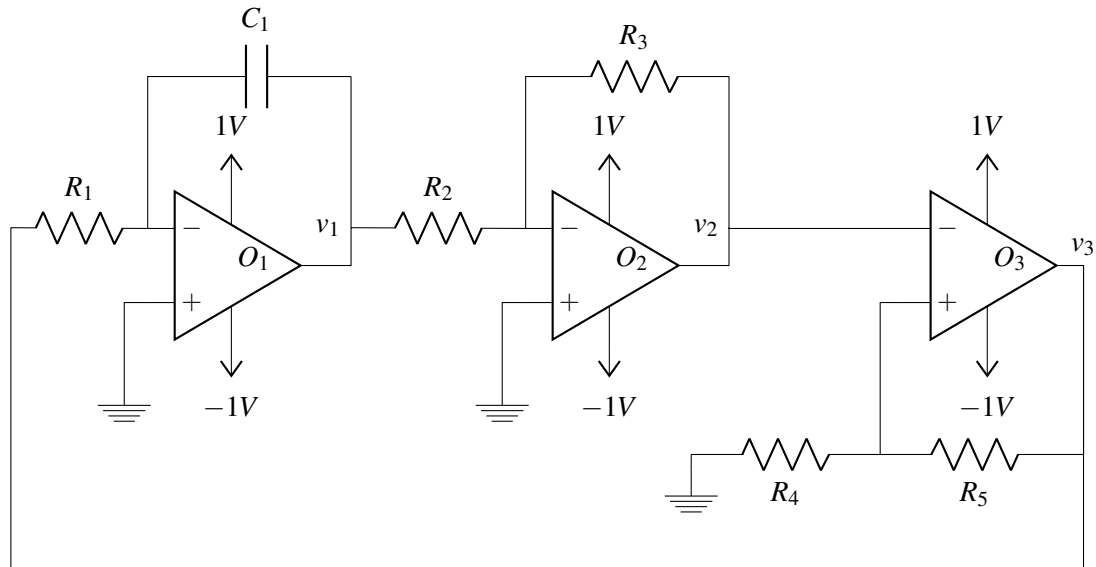## 1. Timer Circuits

In this problem, we will walk through the timer circuit, shown below, similar to the one seen in lecture. The circuit is shown below. All resistors have value $1k\Omega$ and $C_1 = 1\mu F$.

(a) Find the current through the capacitor C_1 in terms of the voltage V_3 and the resistor R_1.

(b) Suppose at time $t = 0$, C_1 is uncharged. Find the voltage v_1 in terms of t, v_3, and R_1. What is the maximum $|v_1|$ could be?

(c) How is v_2 related to v_1? What is the voltage v_2?

Opamp O_3 is not connected in negative feedback. We can however analyze it's behavior by considering it to be a comparator. Let's independently analyze the circuit in the two possible outputs of the comparator.

(d) Assume the output of the comparator V_3 has railed to the top rail. With this value of v_3, what is v_2 as a function of time? What is the voltage at the positive input of opamp O_3? At what time will the two inputs of the comparator be equal?

(e) Now assume the reverse occurs, the input of the comparator has railed to the top rail. Repeat part d) with this value of v_3.

(f) What is the v_3 as a function of time? Draw a graph of v_3 and v_2. This circuit is periodic, find it's period and frequency.

(g) Suppose we changed the value of C_1 to be $2\mu F$? What is the new period? Suppose we change R_5 to be $2k\Omega$. What is the new period? What if we change R_5 to be 0Ω? Will this circuit still operate?