EENG 281 Homework #5 Solutions
Fall 2013

P 5.6 [a] $$i_2 = \frac{150 \times 10^{-3}}{2000} = 75\,\mu\text{A}$$

$$v_1 = -40 \times 10^3 i_2 = -3\,\text{V}$$

[b] $$\frac{v_1}{20{,}000} + \frac{v_1}{40{,}000} + \frac{v_1 - v_o}{50{,}000} = 0$$

$$\therefore \quad v_o = 4.75 v_1 = -14.25 \;\; \text{V}$$

[c] $i_2 = 75\,\mu\text{A}$, (from part [a])

[d] $$i_o = \frac{-v_o}{25{,}000} + \frac{v_1 - v_o}{50{,}000} = 795\,\mu\;\text{A}$$

P 5.26 Use voltage division to find v_p:

$$v_p = \frac{2000}{2000 + 8000}(5) = 1 \text{ V}$$

Write a KCL equation at v_n and solve it for v_o:

$$\frac{v_n - v_a}{5000} + \frac{v_n - v_o}{R_f} = 0 \qquad \text{so} \qquad \left(\frac{R_f}{5000} + 1\right) v_n - \frac{R_f}{5000} v_a = v_o$$

Since the op amp is ideal, $v_n = v_p = 1$V, so

$$v_o = \left(\frac{R_f}{5000} + 1\right) - \frac{R_f}{5000} v_a$$

To satisfy the equation,

$$\left(\frac{R_f}{5000} + 1\right) = 5 \qquad \text{and} \qquad \frac{R_f}{5000} = 4$$

Thus, $R_f = 20$ kΩ.

P 5.36 It follows directly from the circuit that $v_o = -(120/7.5)v_g = -16v_g$

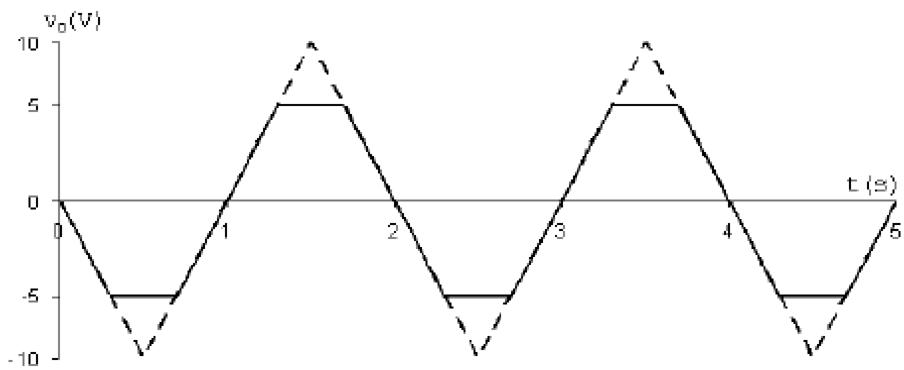
From the plot of v_g we have $v_g = 0, \quad t < 0$

$$\begin{aligned} v_g &= t && 0 \le t \le 0.5 \\ v_g &= 1 - t && 0.5 \le t \le 1.5 \\ v_g &= t - 2 && 1.5 \le t \le 2.5 \\ v_g &= 3 - t && 2.5 \le t \le 3.5 \\ v_g &= t - 4 && 3.5 \le t \le 4.5, \quad \text{etc.} \end{aligned}$$

Therefore

$$\begin{aligned} v_o &= -16t && 0 \le t \le 0.5 \\ v_o &= 16t - 16 && 0.5 \le t \le 1.5 \\ v_o &= 32 - 16t && 1.5 \le t \le 2.5 \\ v_o &= 16t - 48 && 2.5 \le t \le 3.5 \\ v_o &= 64 - 16t && 3.5 \le t \le 4.5, \quad \text{etc.} \end{aligned}$$

These expressions for v_o are valid as long as the op amp is not saturated. Since the peak values of v_o are ± 5, the output is clipped at ± 5. The plot is shown below.



P 5.39 [a] $$p_{16\,\text{k}\Omega} = \frac{(320\times 10^{-3})^2}{(16\times 10^3)} = 6.4\,\mu\text{W}$$

[b] $$v_{16\,\text{k}\Omega} = \left(\frac{16}{64}\right)(320) = 80\,\text{mV}$$

$$p_{16\,\text{k}\Omega} = \frac{(80\times 10^{-3})^2}{(16\times 10^3)} = 0.4\,\mu\text{W}$$

[c] $$\frac{p_\text{a}}{p_\text{b}} = \frac{6.4}{0.4} = 16$$

[d] Yes, the operational amplifier serves several useful purposes:

- First, it enables the source to control 16 times as much power delivered to the load resistor. When a small amount of power controls a larger amount of power, we refer to it as *power amplification*.
- Second, it allows the full source voltage to appear across the load resistor, no matter what the source resistance. This is the *voltage follower* function of the operational amplifier.
- Third, it allows the load resistor voltage (and thus its current) to be set without drawing any current from the input voltage source. This is the *current amplification* function of the circuit.