# nlnmul.exe Exercises for Chapter nlnmul

### Exercise nlnmul.rhinoceros

Write a one- or two-sentence response to each of the following questions and imperatives. The use of equations is acceptable when they appear in a sentence. Don't quote me (use your own words, other than technical terminology).

(a) Write the equivalent impedance of a resistor $R$ and an inductor $L$ in series. Express the result in rectangular and polar (phasor) form.
(b) How do you find the Norton equivalent resistance?
(c) Explain how a diode operates in forward-bias.
(d) In a MOSFET, how much current will flow from the drain $D$ to the source $S$ when the gate-source voltage is $0.3$ V? Succinctly explain/justify.

### Exercise nlnmul.flamingo

Write a one- or two-sentence response to each of the following questions and imperatives. The use of equations is acceptable when they appear in a sentence. Don't quote me (use your own words, other than technical terminology).

(a) Describe a couple differences between MOSFETs and opamps.
(b) If a DC source is connected to a circuit in steady state, describe how an inductor in the circuit will be operating.
(c) If a transformer increases an AC signal's voltage by a factor of $119$, what happens to the signal's current?
(d) How do we determine the diode resistance for the piecewise linear model of a diode?

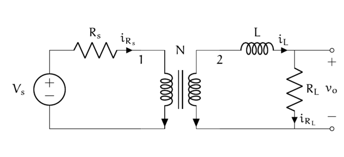



**Figure exe.1:** circuit diagram for Exercise nlnmul. and Exercise nlnmul..

### Exercise nlnmul.astringent

Write a one- or two-sentence response to each of the following questions and imperatives. The use of equations is acceptable when they appear in a sentence. Don't quote me (use your own words, other than technical terminology).

(a) If the current through an inductor is suddenly switched off, what happens?
(b) Let the output voltage of a resistor circuit be 5 V and the equivalent resistance $500\ \Omega$. What is the Thevenin equivalent circuit?
(c) In the preceding part of this question, what is the Norton equivalent?
(d) When can we use impedance analysis?

### Exercise nlnmul.prolongate

For the circuit diagram of Fig. exe.1, solve for $v_o(t)$ if $V_s(t) = A\cos\omega t$. Let $N = n_2/n_1$, where $n_1$ and $n_2$ are the number of turns in each coil, 1 and 2, respectively. Also let $i_L(0) = 0$ be the initial condition.

### Exercise nlnmul.synopses

Re-do Exercise nlnmul., but only consider the steady-state response. Use impedance methods!

### Exercise nlnmul.horklump

Calculate the current through a diode using the ideal model under the following conditions,

$$v_D = 5, 8, -3 \text{ V}$$
$$T = 38, 21, 28\ °\text{C}.$$

The diode can be assumed to have a saturation current of $I_s = 10^{-12}$ A. You may find the following helpful,

- Boltzmann constant: $1.381 \times 10^{-23}\ \frac{\text{m}^2\text{kg}}{\text{s}^2\text{K}}$, and
- fundamental charge: $1.602 \times 10^{-19}$ C.

### Exercise nlnmul.spartanism

When considering the steady state of circuits with only DC sources, all voltages and currents are constant and all diodes are in constant states (each is ON or OFF). The methods of Lec. nlnmul.dio still apply, of course, but we needn't be concerned with a time evolution. Consider the circuits of Fig. exe.2. For each circuit, solve for the voltage across the $5\ \text{k}\Omega$ resistor. Treat each diode as an ideal diode.

### Exercise nlnmul.outsmart

Repeat Exercise nlnmul., but use the piecewise linear model of each diode.

### Exercise nlnmul.combmaker

**diode clipping circuit**

A diode clipping circuit is one that "clips" the tops and or bottoms of a signal. These circuits can be used to set a maximum or minimum voltage for a signal.
Consider the diode clipping circuit of Fig. exe.3. Source $V_1$ effectively adjusts the maximum possible load voltage $v_{R_L}$, and $V_2$ the minimum. Let $V_S(t) = 10\cos 4\pi t$, $V_1 = 5$ V, $V_2 = -3$ V, and $R_s = R_L = 50\ \Omega$. Solve for $v_{R_L}(t)$. Use the ideal diode model.

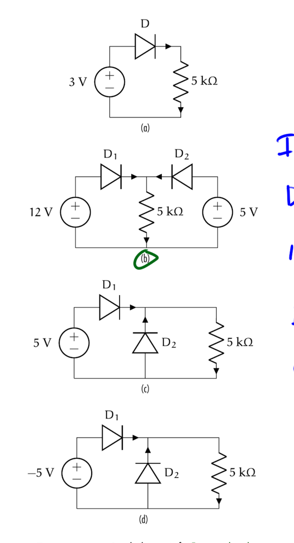



**Figure exe.2:** diode circuits for Exercise nlnmul..

Ideal diode model
$D_1$ on $D_2$ on
$12 = V_R$ $5 = V_R$
$D_2$ on $D_1$ off
$5 = V_R$ $i_{R_2} > 0$
$V_R = i_R R$
$\frac{5}{5000} = i_R > 0$ ✓
$V_{D_1} < 0$ $-5 + 12 = V_{D_1} = 7$
$D_1$ on $D_2$ off
$12 = V_R = i_R R$
$\frac{12}{5000} = i_R > 0$ ✓
$V_{D_2} < 0$
$V_{D_2} = -12 + 5 = -7 < 0$ ✓

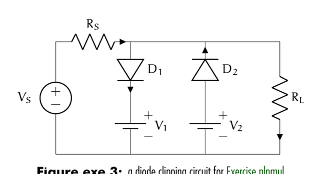



**Figure exe.3:** a diode clipping circuit for Exercise nlnmul..

### Exercise nlnmul.cloisteral

Repeat Exercise nlnmul., but use the piecewise linear model of each diode.

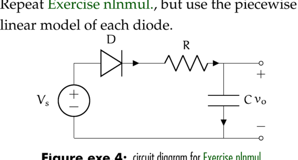



**Figure exe.4:** circuit diagram for Exercise nlnmul..

### Exercise nlnmul.diaspora

For the circuit diagram of Fig. exe.4, solve for $v_o(t)$ if $V_s(t) = A$ for some given $A > 0.6$ V. Let $v_C(t)|_{t=0} = 0$ V be the initial condition. Use a piecewise linear model for the diode with some $R_d \in \mathbb{R}_{\geqslant 0}$. Do not estimate $R_d$.

### Exercise nlnmul.porosity

For the circuit shown in Fig. exe.5, determine the voltage across the load $v_{R_L}$ in terms of parameters and the gate voltage source voltage $V_g$ and $V_s$. The parameters of the MOSFET are $K$ and $V_T$. Assume MOSFET saturation operation.

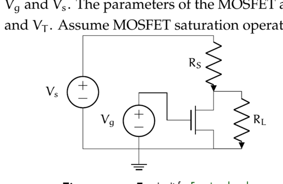



**Figure exe.5:** circuit for Exercise nlnmul..

### Exercise nlnmul.overbroil

The opamp circuit of Fig. exe.6 is used as a voltage-controlled current source for the load $R_L$. Show that it behaves as a current source with current $i_{R_L}$ controlled by voltage source $v_i$. Use two separate methods: (a) assuming $v_+ \approx v_-$ and (b) not assuming $v_+ \approx v_-$, rather, assuming the open loop gain of the opamp $A$ is

large. Comment on the differences between the methods of (a) and (b).

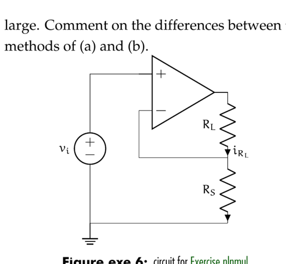



**Figure exe.6:** circuit for Exercise nlnmul..

### Exercise nlnmul.polynucleate

Use the circuit diagram of Fig. exe.7 to answer the questions below. Use the sign convention from the diagram. Let $v_i = A\cos\omega t$ be an ac input voltage. The load $Z_L$ impedance is not given.

(a) Write the elemental equations in terms of $Z_{R_1}$, $Z_{R_2}$, $Z_{R_S}$ and $Z_L$ (the impedances of the components).
(b) Write the KCL and KVL equations.
(c) Solve for the steady-state $v_o(t)$ without inserting the values of the impedances (that is, leave it in terms of $Z_{R_1}$, $Z_{R_2}$, $Z_{R_S}$ and $Z_L$).

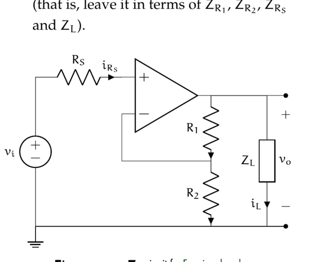



**Figure exe.7:** circuit for Exercise nlnmul..

### Exercise nlnmul.lush

Consider the circuit in Fig. exe.8. Solve for $v_o(t)$ for input voltage $v_i(t) = 5$ V, a sine wave of $v_i(t) = 5\sin 25t$, and a sine wave of $v_i(t) = 5\sin 2525t$. Let $R_1 = 50\ \Omega$, $R_2 = 10\ \text{k}\Omega$, $C = 10\ \mu\text{F}$, and the opamp open-loop gain be $A = 10^5$. Let the initial condition be $v_C(t) = 0$ V. In each case, plot the solution to show the transient response until it reaches steady-state.

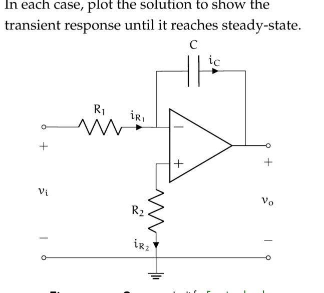



**Figure exe.8:** opamp circuit for Exercise nlnmul.

### Exercise nlnmul.hogwash

Consider the circuit in Fig. exe.9. Solve for $v_o(t)$ for a known input voltage $v_i(t)$.

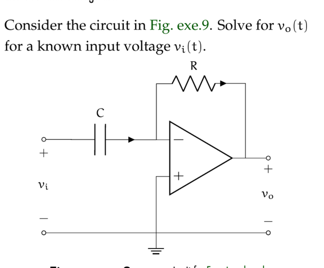



**Figure exe.9:** opamp circuit for Exercise nlnmul.

### Exercise nlnmul.virtue

In each of the figures of Fig. exe.10, solve for the voltage $v_{100}$ across the $100\ \Omega$ resistor. Use the assumptions in the associated caption. Clearly justify each response.

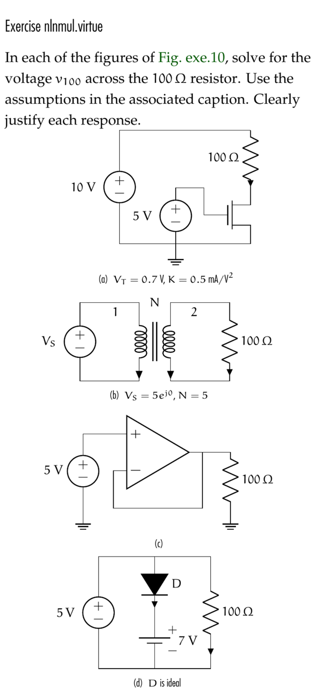
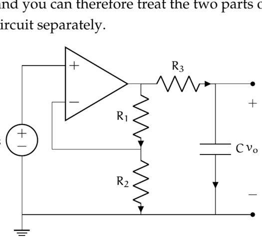



**Figure exe.10:** circuits for Exercise nlnmul..

### Exercise nlnmul.nonabstract

Consider the circuit below with input voltage sources $V_S$ and $V_g$. Determine $V_g$ such that the load voltage $v_{R_L} = 10$ V. Let $R_L = 2\ \text{k}\Omega$, $K = 0.5\ \text{mA/V}^2$, $V_T = 0.7$ V, $V_s = 20$ V.




### Exercise nlnmul.ear

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Consider the circuit below with input voltage source $V_S(t) = A$ where $A > 0$ is a known (but unspecified) constant. Perform a circuit analysis to solve for $v_o(t)$ for the initial condition $v_C(0) = 0$. Hint: it is easier if you realize the opamp output voltage is effectively an ideal voltage source (so it does not depend on $v_{R_3}$ and $v_C$) and you can therefore treat the two parts of the circuit separately.




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