Physics 2250: Problem Set V

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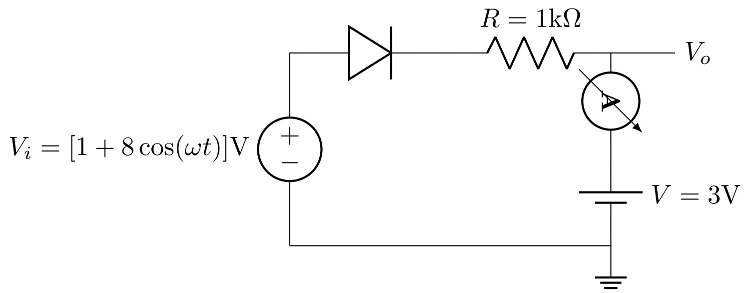
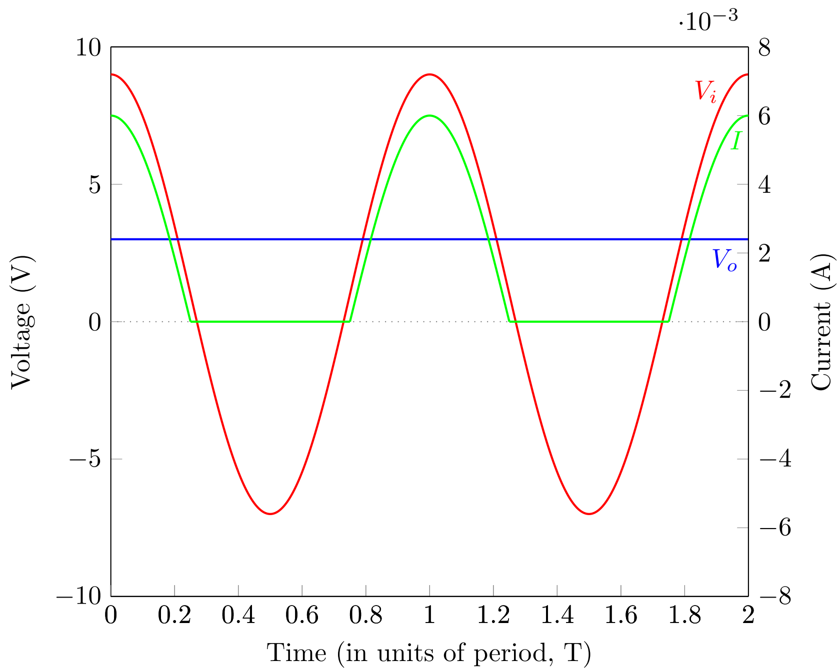
Problem 1. Consider the circuit below: V_i is a periodic signal; $V_i = [1 + 8\cos(\omega t)]$.

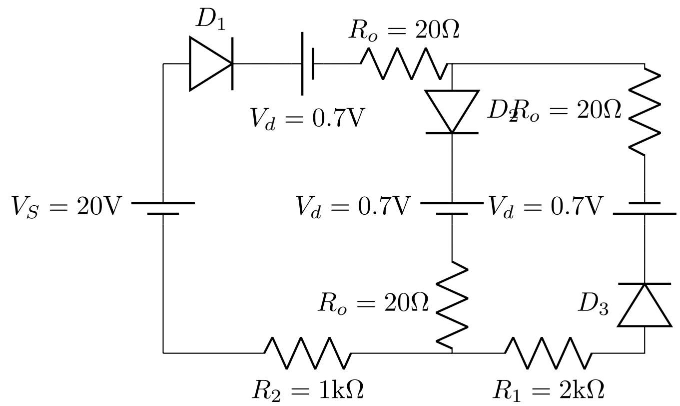


Solution 1. a & b)



V_o and V_i are effectively given by the problem. I (at peak) is given by $\dfrac{V_i - V}{R} = 6\text{mA}$ because the two sources will "fight" when the diode is maximally forward-biased. When the diode is reverse-biased, there will be no current whatsoever as both sources will cooperate and try to push current backwards across the diode.

Problem 2. Determine the current passing through each of the three diodes in the circuit shown below.

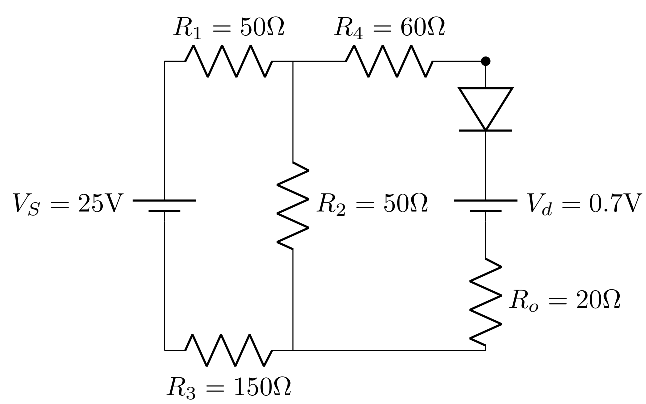


Solution 2. Right off the bat D_3 is reverse-biased so sees no current. This leaves a simple single-loop circuit (through which current is conserved) so

$$
\begin{aligned}
0 &= 20\text{V} - 0.7\text{V} - IR_o - 0.7\text{V} - IR_o - IR_2 \\
\frac{1.4\text{V} - 20\text{V}}{-2R_o - R_2} &= I \approxeq 9.12\text{mA}
\end{aligned}
$$

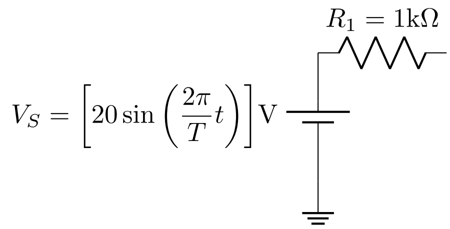
So D_1 and D_2 experience a current of ≈ 9.12mA and D_3 experiences no current (because it is reverse-biased).

Problem 3. Determine the current passing through each of the three diodes in the circuit shown below.

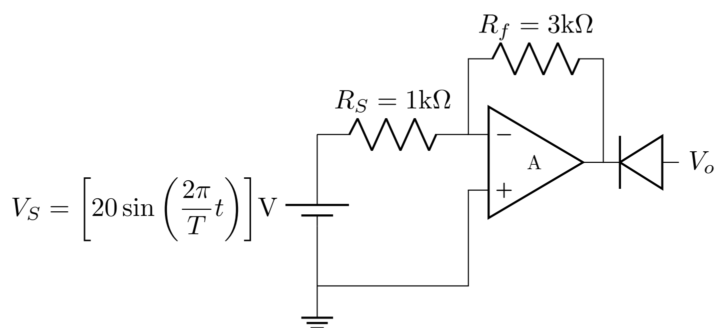


Solution 3. Because the V_d source can push no current through the diode the total current is given by $I = \dfrac{V_S}{R_1 + R_3 + \left(R_2^{-1} + [R_4 + R_o]^{-1}\right)^{-1}} = \dfrac{13}{120}$A. This current is split between the R_2 and R_4 branches by the current divider $I_{R4} = I\dfrac{R_2}{R_4 + R_2 + R_o} = \dfrac{1}{24}$A so the power dissipated by R_o is $P = I_{R_4}^2 R_o \approxeq 34.7$mW.

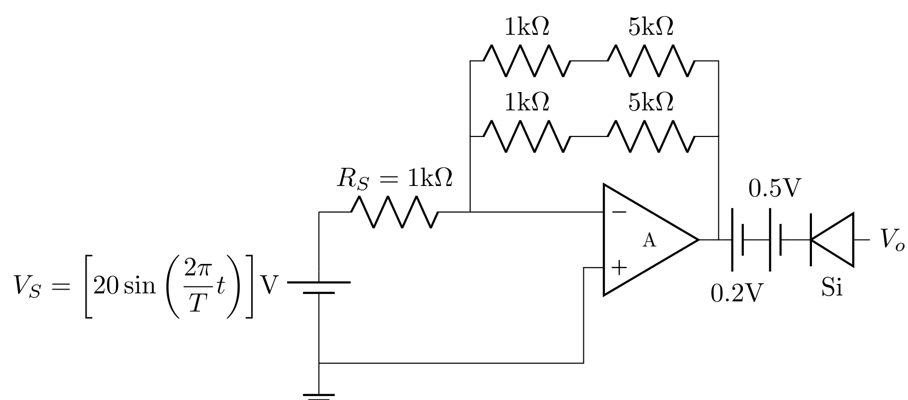
Problem 4. Consider a sinusoidal voltage supply with $V_S = \left[20 \sin\left(\frac{2\pi}{T}t\right)\right]$ V and a resistance $R_S = 1\text{k}\Omega$, as shown in the figure below.



Solution 4.
a) To transform the given V_S into the desired V_o we need to invert it, triple it, and clip the positive voltages. To do this we can make use of an op amp in the inverting configuration and a diode that is reverse biased when the output of that op amp (three times the negative of the input voltage) is greater than zero.



b) We can reuse the logic behind the first circuit but we now need to offset the voltage drop across the now non-ideal diode and figure out a way to recreate the $3:1$ resistor ratio. We can offset the diode voltage drop with a 0.2V battery and a 0.5V battery in series and we can recreate the $3\text{k}\Omega$ resistor by using a pair of $1\text{k}\Omega$ and $5\text{k}\Omega$ resistors in parallel.



Both a) and b) assume that the op amps have no maximum (or minimum) voltage output because I can't think of a way to create the required amplification otherwise.