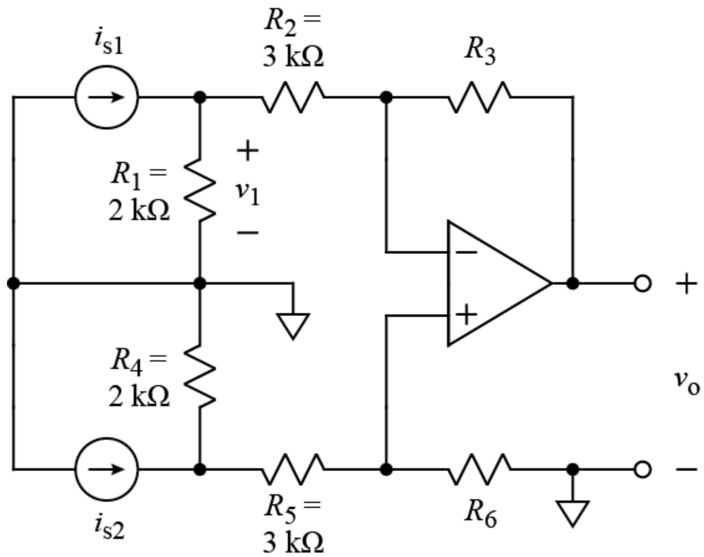
Homework 20

1.



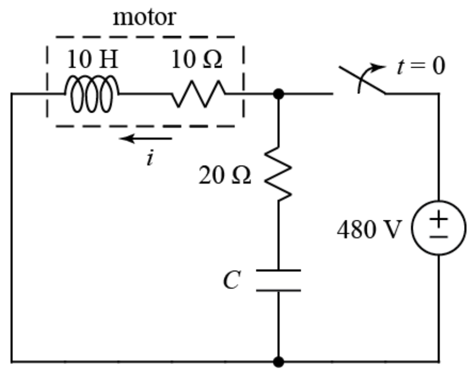
a) The above circuit operates in linear mode. Derive a symbolic expression for v_o. The expression must contain not more than the parameters i_{s1}, i_{s2}, R_1, R_2, R_3, R_4, R_5, and R_6.

b) Assuming $R_1 = R_4$, $R_2 = R_5$, and $R_3 = R_6$ derive a symbolic expression for v_o in terms of common mode and differential input voltages:

$$i_{cm} \equiv \frac{(i_{s2} + i_{s1})}{2} \qquad \text{and} \qquad i_{dm} \equiv i_{s2} - i_{s1}$$

The expression must contain not more than the parameters i_{cm}, i_{dm}, R_1, R_2, and R_3. Write the expression as i_{cm} times a term plus i_{dm} times a term.

2.



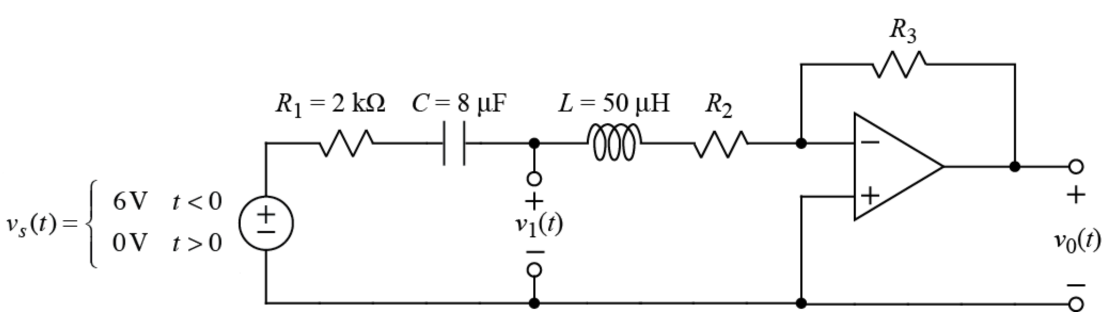
After being closed for a long time, the switch opens at $t = 0$.

The above circuit represents a simplified circuit model of a motor and its power supply. The switch opens at time $t = 0$ to turn off the motor, and resistor R_2 and C provide a discharge path for current in the motor.

a) Find the smallest **standard value** of C that makes the circuit over-damped after the switch is opened at $t = 0$. For standard values, assume the value of C is of form $\mathbf{1 \cdot 10^{n}}$ **F** or $\mathbf{2 \cdot 10^{n}}$ **F** or $\mathbf{5 \cdot 10^{n}}$ **F** where n is an integer.

b) Using the C value from (a), find a numerical expression for the motor current, $i(t)$, for $t > 0$.

3.



The voltage source in the above circuit is off for $t > 0$.

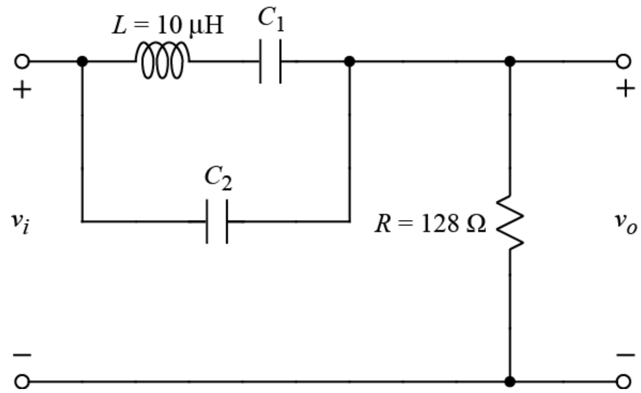
a) Find a symbolic expression for the Laplace-transformed output, $\mathbf{V}_0(s)$, in terms of not more than R_1, R_2, R_3, L, C, and values of sources or constants.

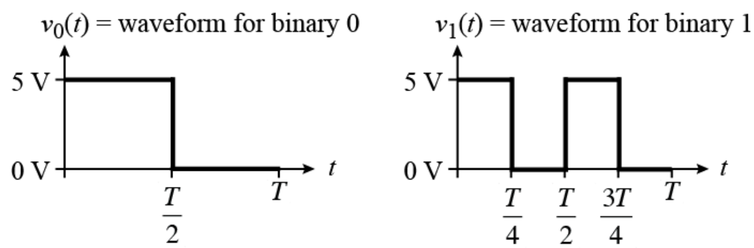
b) Choose a numerical value for R_2 to make

$$v_1(t) = v_m e^{-\alpha t} \cos(\beta t)$$

where v_m, α, and β are real-valued constants.

4.





T = one period of $v_0(t)$ = 6.28 μs

$$v_0(t) = \begin{cases} 5\text{ V} & 0 \le t < T/2 \\ 0\text{ V} & T/2 \le t < T \end{cases} \qquad v_1(t) = \begin{cases} 5\text{ V} & 0 \le t < T/4 \text{ and } T/2 \le t < 3T/4 \\ 0\text{ V} & T/4 \le t < T/2 \text{ and } 3T/4 \le t < T \end{cases}$$

The above filter circuit is being used in a communication system to detect whether received signals represent binary zeros or binary ones. The waveforms are designed to be detected using a method that determines whether the signal is high or low in each segment of length $T/4$, but only the analog filter circuit shown above is available.

The plan is to use the filter shown above to detect waveforms for zeros by designing the filter to pass the fundamental frequency, $\omega_0 = 2\pi/T$, of $v_0(t)$ but block the fundamental frequency, $2\omega_0$, of $v_1(t)$. (Presumably a different filter would be designed to detect waveforms for ones, but that filter is of no concern here.)

a) Find values of $C_1 \neq 0$ and $C_2 \neq 0$ such that the magnitude of the filter's transfer function, H, equals one for the fundamental frequency, ω_0, of $v_0(t)$ and zero for frequency $2\omega_0$.

b) Find the magnitude of the filter transfer function for frequency $6\omega_0$. (This frequency is present in $v_1(t)$, and it is desirable that it also be suppressed to a large degree.)

5. Make up a problem for the final exam and solve it.