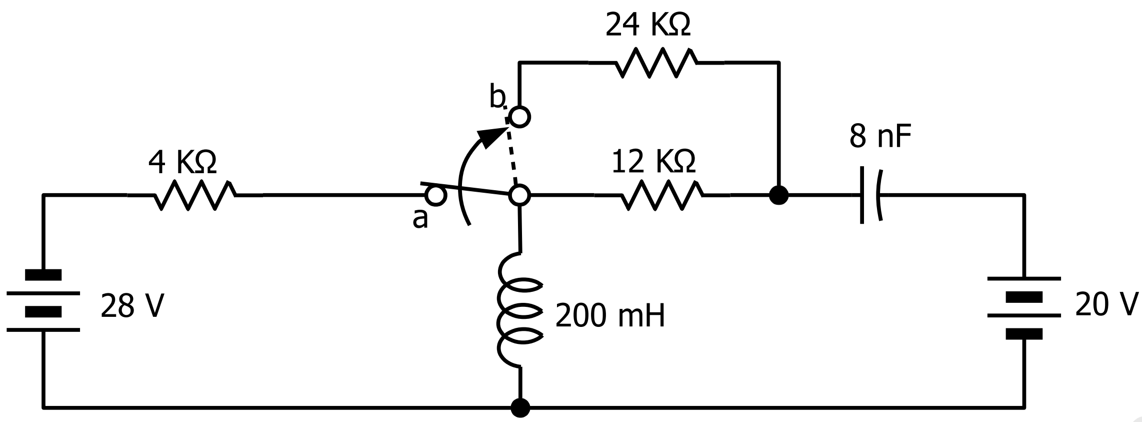
EE3 Fall 2017
Final Exam Practice Problems



1. The switch has been in position a for a long time. All transients have died out. At t = 0, the switch moves instantaneously to position b.

   a. At $t=0^-$ (the last instant that the switch is in position a), what is the current through the capacitor? 0 A

   b. At $t=0^-$ (the last instant that the switch is in position a), what is the voltage across the capacitor? $-20+v_C(0^-)+0+0=0$; $v_C(0^-)=20$ V, + at rt end

   c. At $t=0^+$ (the first instant that the switch is in position b), what is the current through the capacitor? $I_C(0^+) = 28$ V / 4 KΩ = 7 mA (L to R)

   d. At $t=0^+$ (the first instant that the switch is in position b), what is the voltage across the inductor?

   KVL CW: $v_C(0^+)+20-v_L(0)+(8K)(7mA)=0$; $v_L(0^+)=+56$ V; + at top

   e. When the switch has been in position b for a long time, what is the voltage across the inductor? 0 V

   g. When the switch has been in position b for a long time, what is the voltage across the capacitor? 20 V, + at right end

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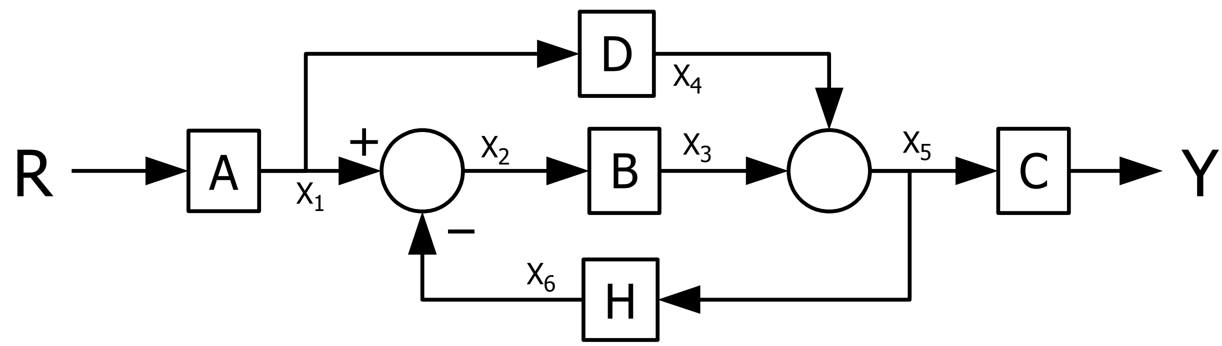

2. Find the transfer function Y/R (this will be a function of A, B, C, D, and H). Hint: assign a name, such as X_1, to the output of each block. Then find the expression for each block output. After that, it's algebra.

$$X_1 = AR$$
$$X_2 = X_1 - X_6$$
$$X_3 = BX_2 = BX_1 - BX_6 = ABR - BX_6$$
$$X_4 = DX_1 = ADR$$
$$X_5 = X_3 + X_4 = ABR - BX_6 + ADR$$
$$X_6 = HX_5 = H\left(ABR - BX_6 + ADR\right) = ABHR - BHX_6 + ADHR$$
$$X_6\left(1 + BH\right) = ABHR + ADHR$$
$$X_6 = \frac{ABHR + ADHR}{1 + BH} = \left(\frac{ABH + ADH}{1 + BH}\right)R$$
$$Y = CX_5 = C\left(ABR - BX_6 + ADR\right) = ABCR - BCX_6 + ACDR$$
$$Y = \left(ABC\right)R - \left[BC\left(\frac{ABH + ADH}{1 + BH}\right)\right]R + \left(ACD\right)R$$
$$\frac{Y}{R} = ABC - \left(\frac{ABCH}{1 + BH}\right)\left(B + D\right) + ACD$$

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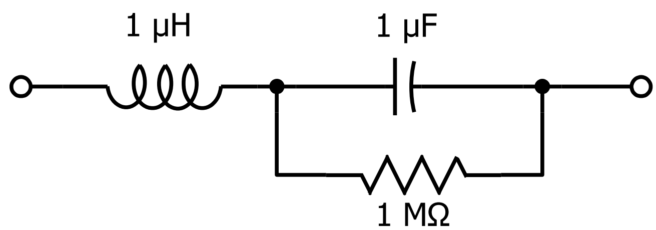


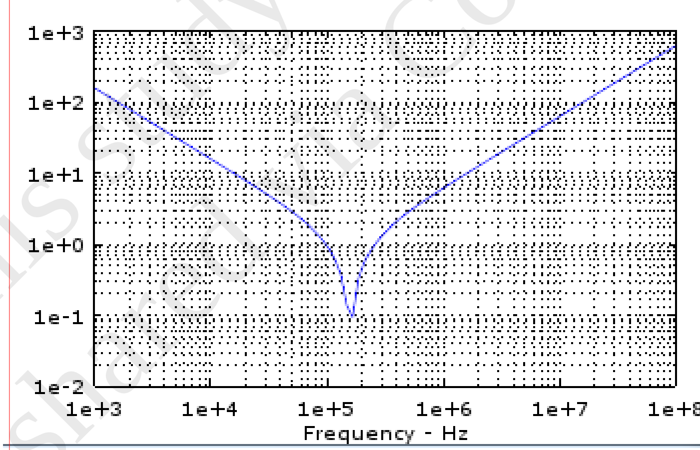
3. This is a more-realistic model of a 1 μF capacitor. The capacitor leads have inductance (1 μH), and the dielectric between the capacitor plates is less than perfect (1 MΩ). Find the frequency where the capacitor stops being a capacitor and starts being an inductor (AKA the series resonant frequency).

At the resonant frequency ω_0, $X_L = X_C$

$$\omega_0 L = \frac{1}{\omega_0 C}$$

$$\omega_0 = \frac{1}{\sqrt{(LC)}} = 1e6 \text{ rad/s)}$$

$$f_0 = \frac{\omega_0}{2\pi} = 159 \text{ KHz}$$



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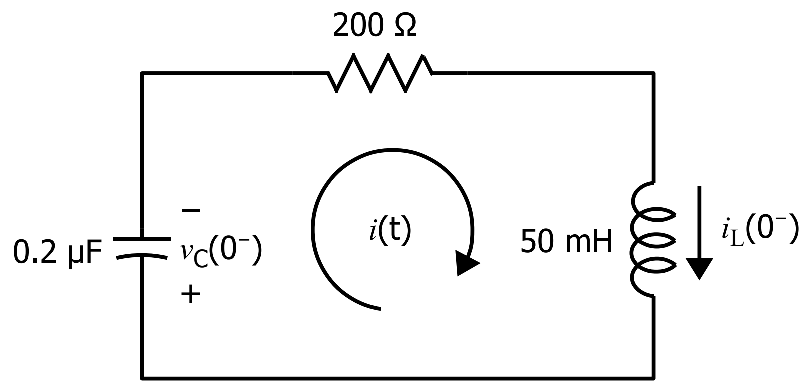
4. This is a second-order circuit. There is an initial voltage on the capacitor (assuming clockwise current) $v(0^-)=+12$ V, and an initial current in the inductor $i_L(0^-)=30$ mA clockwise. In order to solve the differential equation for i(t), the initial voltages $v_L(0^+)$ and $v_R(0^+)$, and $di(t)/dt|_{t=0^+}$ must be found. Using what you know about inductors, capacitors, and KCL, find these values.



$i(0^+) = i_L(0^-) = 30$ mA

$v_C(0^+) = v_C(0^-) = 12$ V

$v_R(0^+) = i(0^+)R = 0.030 \bullet 200 = 6$ V, + to left

KVL@t=0^+: $+6+12+v_L(0^+) = 0$

$v_L(0^+) = -18$ V

Because $v_L(0^+) = L\left.\dfrac{di(t)}{dt}\right|_{t=0^+}$

$$\left.\frac{di(t)}{dt}\right|_{t=0^+} = \left(\frac{1}{0.05}\right)\bullet(-18) = -360 \text{ A/s}$$

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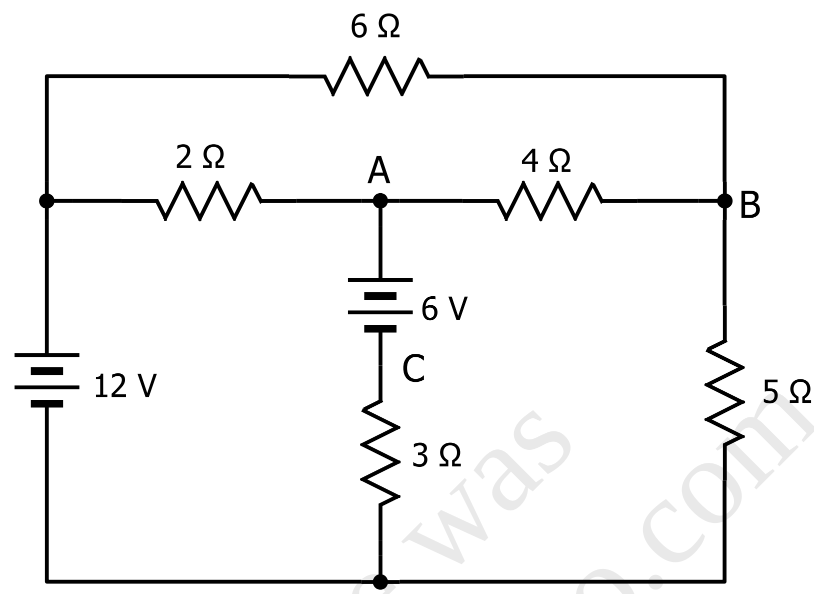
5. Find the power dissipated by the 5 Ω resistor.



9.47 W

$$\frac{V_A-12}{2}+\frac{V_C}{3}+\frac{V_A-V_B}{4}=0$$
$$\frac{V_B-V_A}{4}+\frac{V_B}{5}+\frac{V_B-12}{6}=0$$
$$V_C=V_A-6$$

$$0.75V_A-0.25V_B+0.333V_C=6$$
$$-0.25V_A+0.617V_B=2$$
$$V_A-V_C=6$$

$$V_A=8.97\ \text{V}$$
$$V_B=6.88\ \text{V}$$
$$V_C=2.97\ \text{V}$$

$$P_5=\frac{(V_B)^2}{5}=\frac{6.88^2}{5}=9.47\ \text{W}$$

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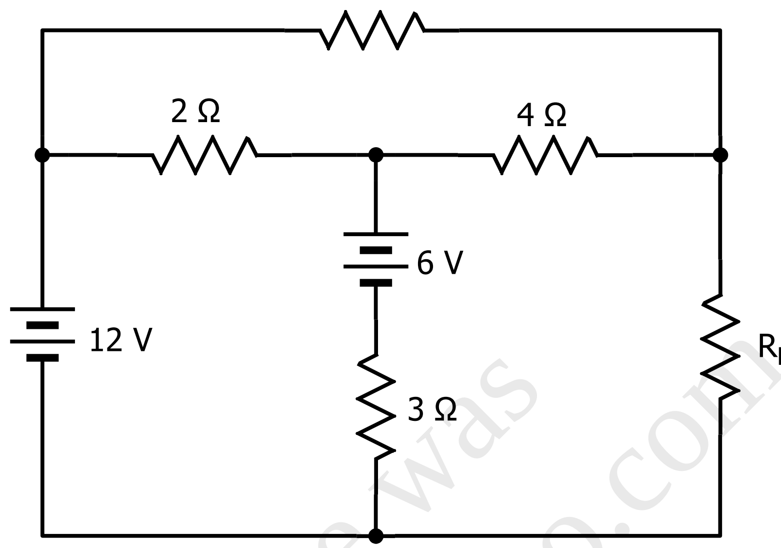
6. Find the value of R_L for maximum power transfer to R_L.



Find the Thévenin Equivalent Resistance.

Open Circuit Voltage

$$V_1 = 12$$

$$\frac{V_2-12}{2}+\frac{V_2-6}{3}+\frac{V_2-V_{OC}}{4}=0$$

$$\frac{V_{OC}-V_2}{4}+\frac{V_{OC}-12}{6}=0$$

$$6V_2-72+4V_2-24+3V_2-3V_{OC}=0$$

$$-3V_2+3V_{OC}+2V_{OC}-24=0$$

$$13V_2-3V_{OC}=96$$

$$-3V_2+5V_{OC}=24$$

$$V_2 = 9.8571\ \text{V}$$

$$V_{OC} = 10.7143\ \text{V}$$

Short Circuit Current

$$\frac{V_1-12}{2}+\frac{V_1-6}{3}+\frac{V_1}{4}=0$$

$$V_1 = 7.3846\ \text{V}$$

$$I_4=\frac{V_1}{4}=1.8462\ \text{A}$$

$$I_6=\frac{12}{6}=2\ \text{A}$$

$$I_{SC}=I_4+I_6=3.8462\ \text{A}$$

$$R_{\text{max\_pwr}}=R_{th}=\frac{V_{OC}}{I_{SC}}=2.79\ \Omega$$

2.79 Ω