EE201 Circuit Theory (Fall 2020)
Final Exam.

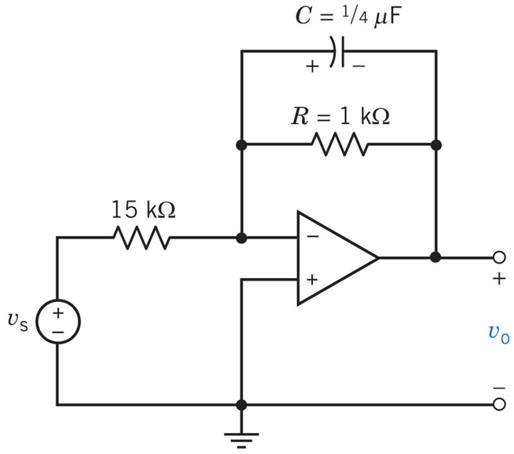
(Total: 240 Points / 8 Problems)

Student ID Number:

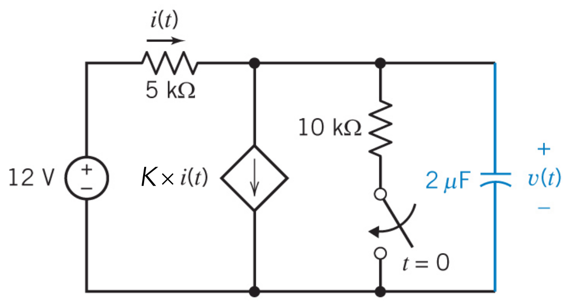
Name:

Prob. 1	Prob. 2	Prob. 3	Prob. 4	Prob. 5	Prob. 6	Prob. 7	Prob. 8	Total
/30	/30	/30	/30	/20	/30	/40	/30	/240

1. **(30 points) Response of a First-Order Circuit to a Nonconstant Source:** A lossy integrator is shown below. The lossless capacitor of the ideal integrator circuit has been replaced with a model for the lossy capacitor, namely, a lossless capacitor in parallel with a 1-kΩ resistor. If $v_s(t) = 8e^{-5t}u(t)$ V and $v_o(0) = 10$ V, find $v_o(t)$ for $t > 0$. Assume that the circuit is at steady state before $t = 0$.



2. **(30 points) Stability of First-Order Circuits:** The first order circuit shown below is at steady state before the switch closes at $t = 0$. This circuit contains a dependent source and so may be unstable. K is a gain of the dependent source.



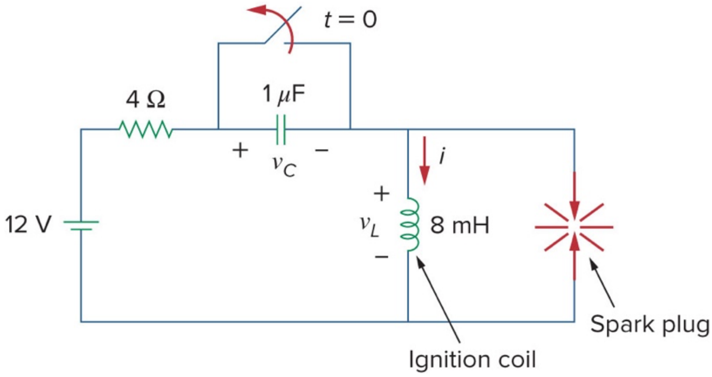
(a) (5 points) Find the initial capacitor voltage at $t = 0$, which is $v(0)$.

(b) (10 points) Determine the Thevenin equivalent for the entire circuit except the capacitor.

(c) (10 points) For $K = 2$, find the capacitor voltage $v(t)$ for $t > 0$. What is the value of $v(t)$ at $t = \infty$, which is $v(\infty)$? Is this circuit stable?

(d) (5 points) What restriction must be placed on K to ensure that the circuit is stable?

3. **(30 points) Automobile Ignition System:** The automobile ignition system is modeled by the circuit shown below. The 12-V source represents the battery, and the 4-Ω resistor models the resistance of the wiring. The ignition coil is modeled by the 8-mH inductor. The 1-μF capacitor is in parallel with the switch.



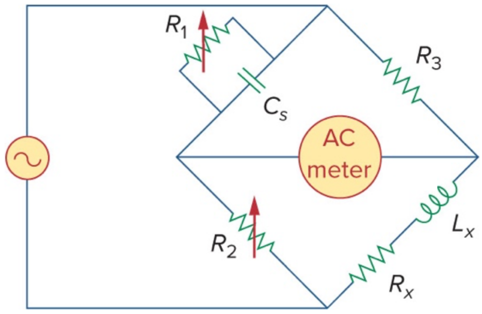
(a) (20 points) Assuming that the switch is closed prior to $t = 0$, find the inductor voltage $v_L(t)$ for $t > 0$.

(b) (5 points) Find the maximum value of $v_L(t)$.

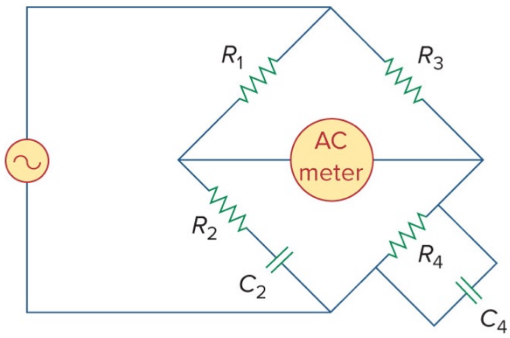
(c) (5 points) Find the capacitor voltage $v_C(t)$ for $t > 0$.

4. **(30 points) AC Bridge Circuits:** Answer the following questions.

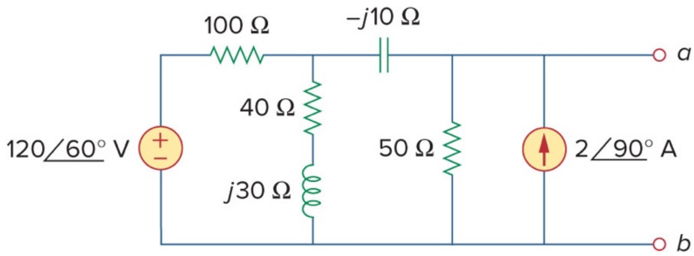
(a) (15 points) The AC bridge circuit shown below is known as a Maxwell bridge and is used for accurate measurement of inductance L_x and resistance R_x of a coil in terms of a standard capacitance C_s. Show that when the bridge is balanced (= when zero current flows through the AC meter), $L_x = R_2R_3C_s$ and $R_x = (R_2/R_1)R_3$.



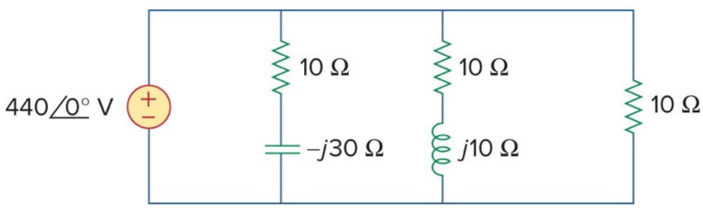
(b) (15 points) The AC bridge circuit shown below is called a Wien bridge. It is used for measuring the frequency of an AC source. Show that when the bridge is balanced, $f = 1/[2\pi(R_2R_4C_2C_4)^{0.5}]$.



5. **(20 points) Maximum Average Power Transfer:** Assuming that the load impedance is to be purely resistive, what load should be connected to terminals *a–b* of the circuit shown below so that the maximum average power is transferred to the load?



6. **(30 points) Power Factor Correction:** For the power system shown below, answer the following questions. Note that the voltage is in RMS value.



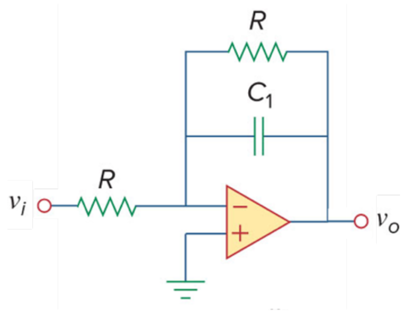
(a) (15 points) Find the total complex power delivered to the entire parallel combination of loads.

(b) (5 points) Calculate the power factor of the entire parallel combination of loads.

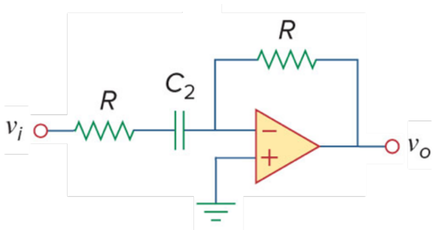
(c) (10 points) Find the value of the parallel capacitance necessary to establish a unity power factor.

7. **(40 points) Filter Circuits:** Answer the following questions.

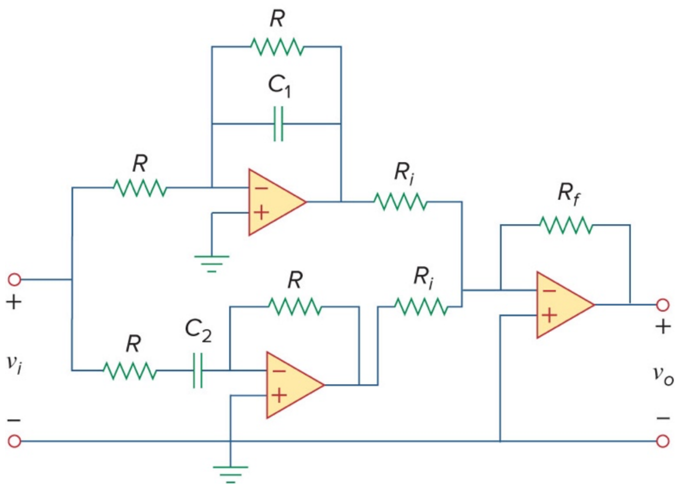
(a) (10 points) Find the transfer function $\mathbf{H}_1(\omega) = \mathbf{V}_o/\mathbf{V}_i$ of the circuit shown below. Which type of filter is it? What is the value of the cutoff frequency ω_1?



(b) (10 points) Find the transfer function $\mathbf{H}_2(\omega) = \mathbf{V}_o/\mathbf{V}_i$ of the circuit shown below. Which type of filter is it? What is the value of the cutoff frequency ω_2?



(c) (10 points) Express the transfer function $\mathbf{H}(\omega) = \mathbf{V}_o/\mathbf{V}_i$ of the following circuit in terms of ω_1 and ω_2. Which type of filter is it, if ω_1 is smaller than ω_2?



(d) (10 points) In (c), find the gain at $\omega = 0$ and ∞. Also find the gain at the center frequency $\omega_0 = (\omega_1\omega_2)^{0.5}$.

8. **(30 points) Bode Plot of a Circuit:** Consider the circuit shown below. The network function that represents this circuit is $\mathbf{H}(\omega) = \mathbf{V}_o/\mathbf{V}_i$ and the corresponding magnitude plot is also shown below. Determine the values of the capacitances C_1 and C_2.