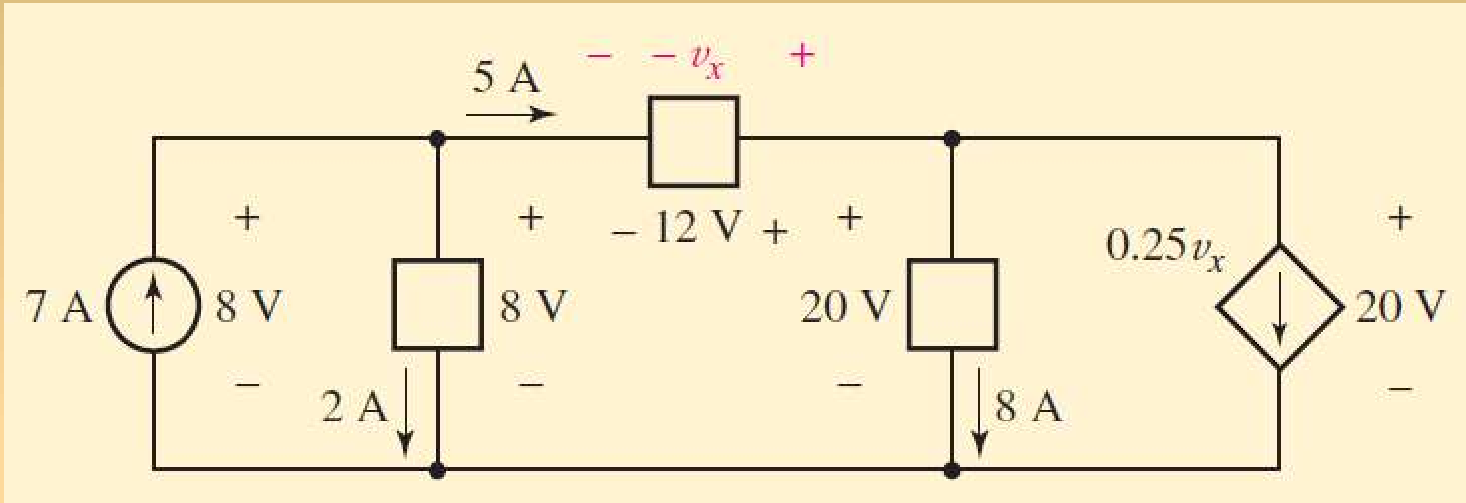
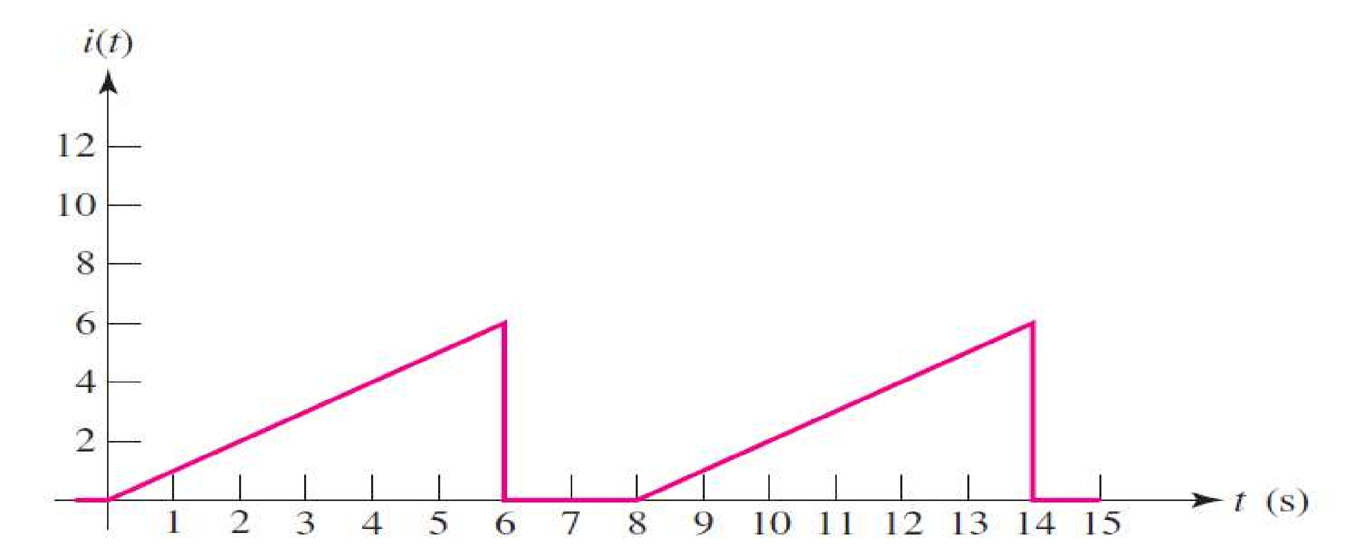
Basic components, voltage & current laws, nodal analysis

Problem - 1



Find the power absorbed by each element in the circuit

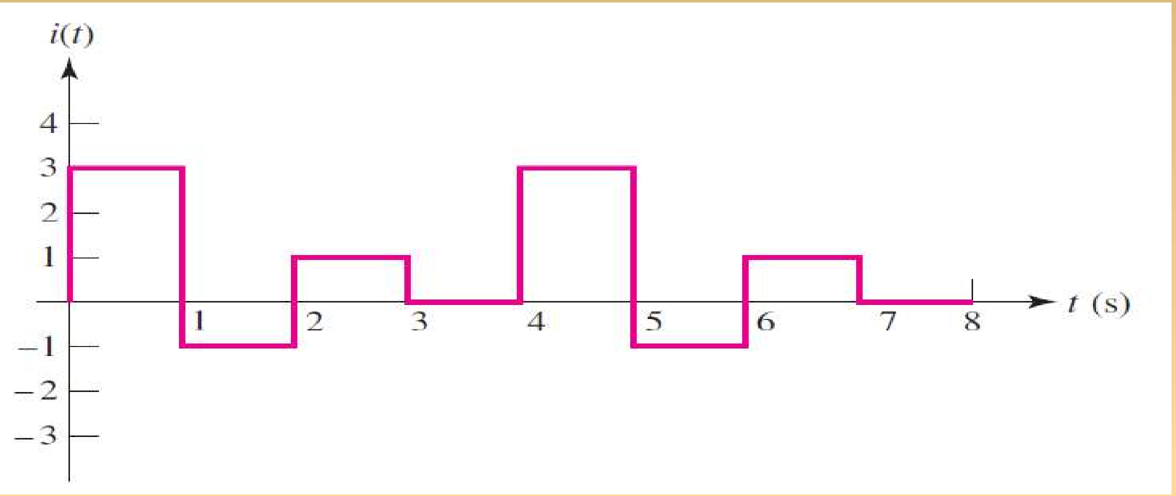
Problem - 2



The current waveform depicted here is characterized by a period of 8 s.

(a) What is the average value of the current over a single period? (b) If q(0) = 0, sketch q(t) for 0 < t < 20 s.

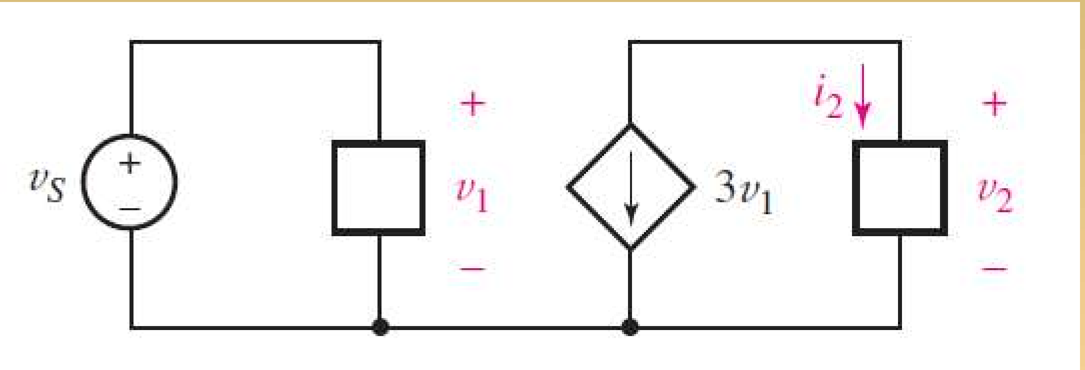
Problem - 3



The current waveform depicted is characterized by a period of 4 s.

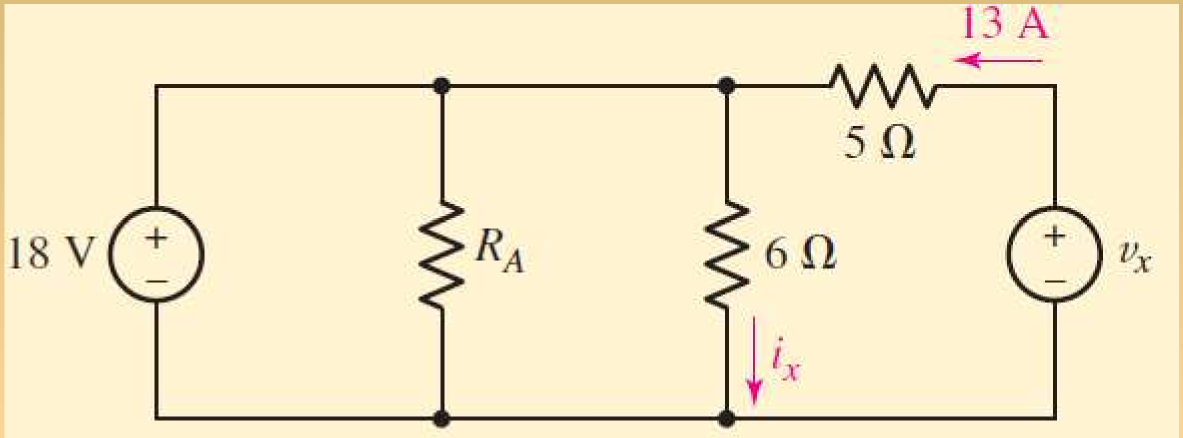
(a) What is the average value of the current over a single period? (b) Compute the average current over the interval 1 < t < 3 s. (c) If q(0) = 1 C, sketch q(t) for 0 < t < 4 s.

Problem - 4



The circuit contains a dependent current source; the magnitude and direction of the current it supplies are directly determined by the voltage labeled v_1. Determine the voltage v1 if $v_2 = 33*i_2$ and $i_2 = 100$ mA.

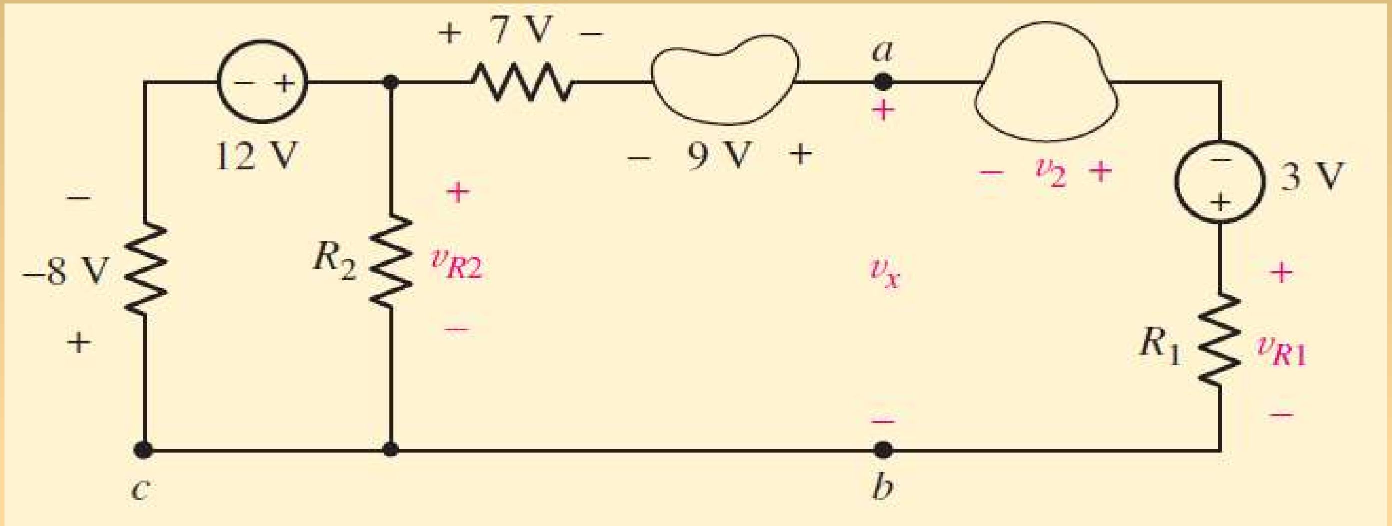
Problem - 5



Count the number of branches and nodes in the circuit.

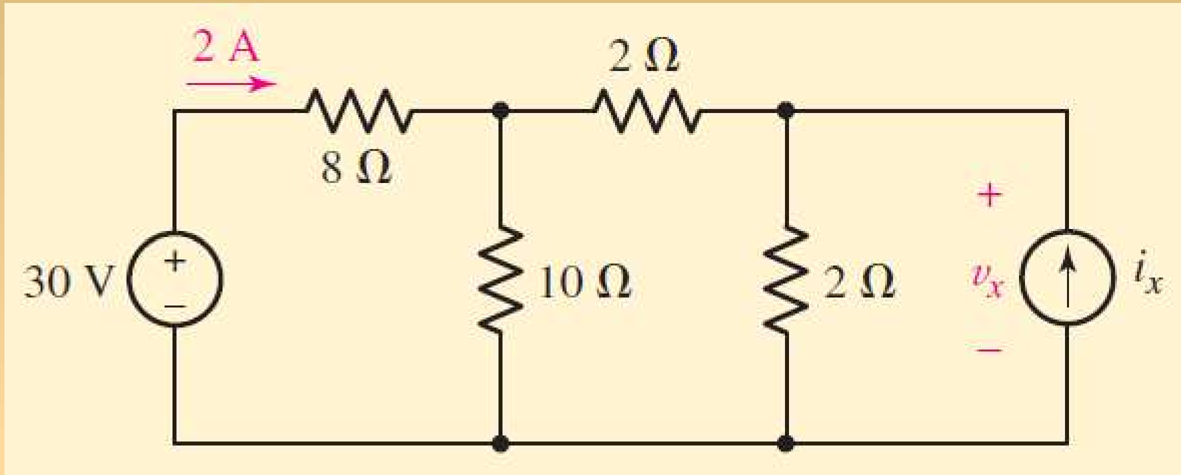
If i_x = 3 A and the 18 V source delivers 8 A of current, what is the value of R_A?

Problem - 6



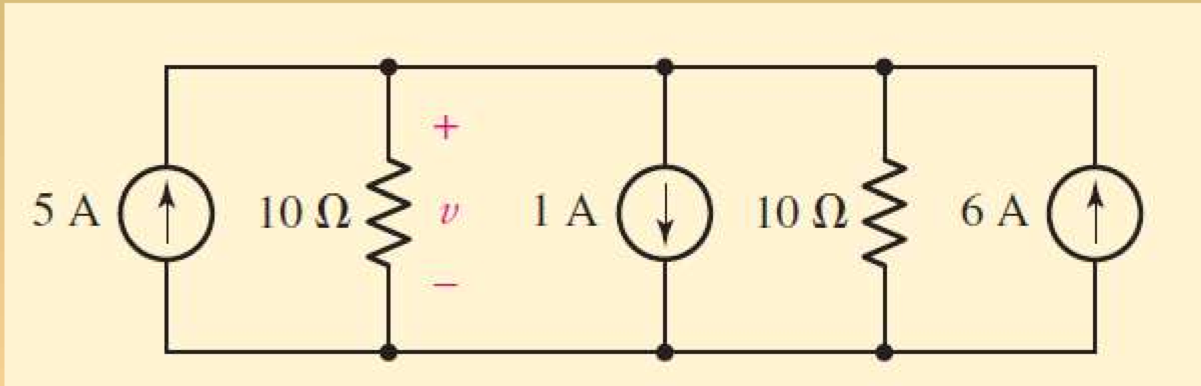
For the circuit, determine (a) v_{R2} and (b) v_2, if v_{R1} = 1 V.

Problem - 7



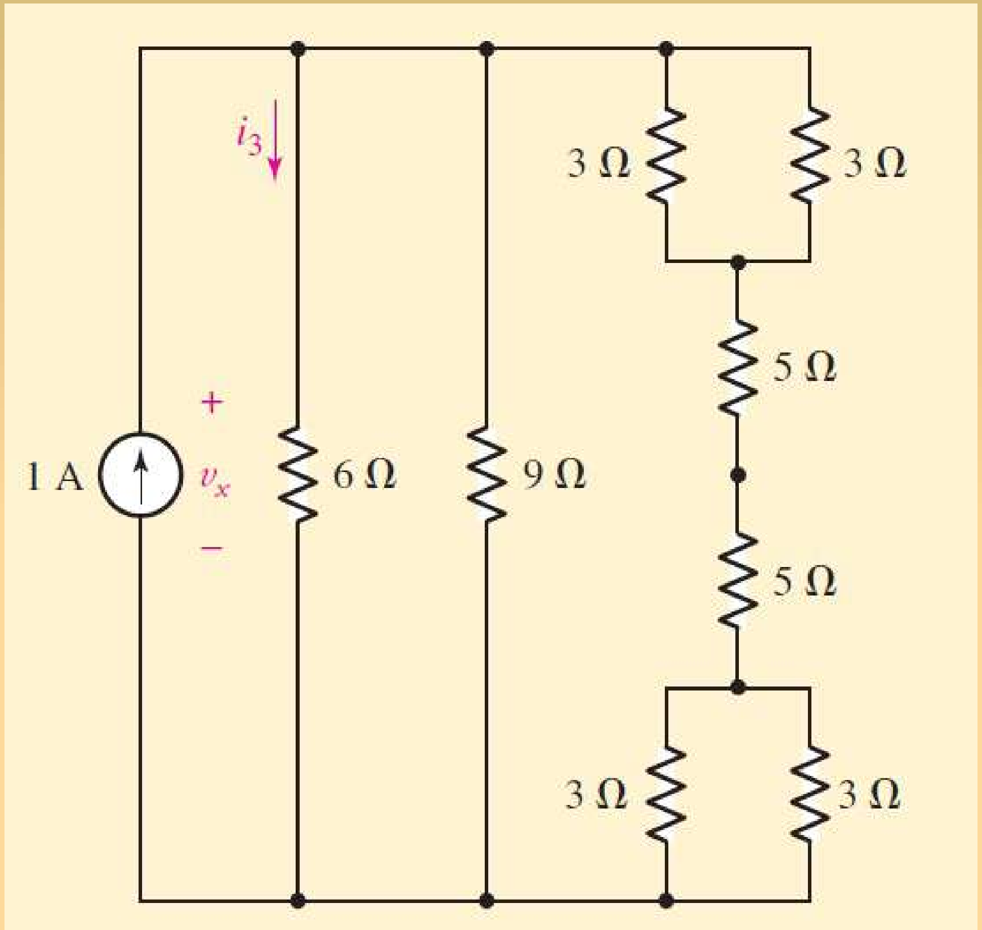
Determine v_x in the circuit

Problem - 8



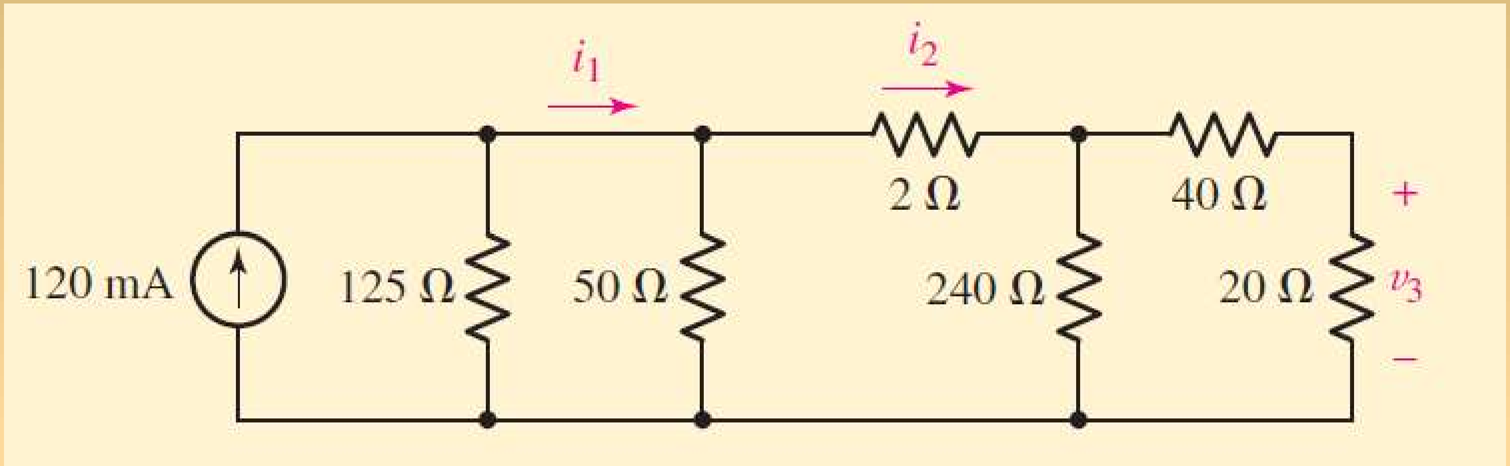
Determine the voltage v in the circuit.

Problem - 9



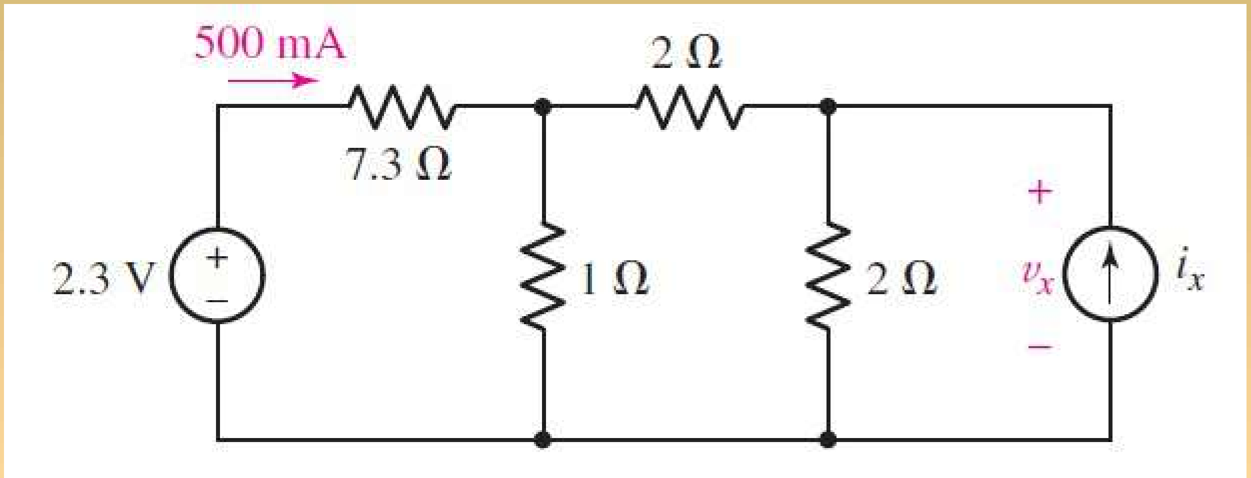
For the circuit, calculate the voltage v_x.

Problem - 10



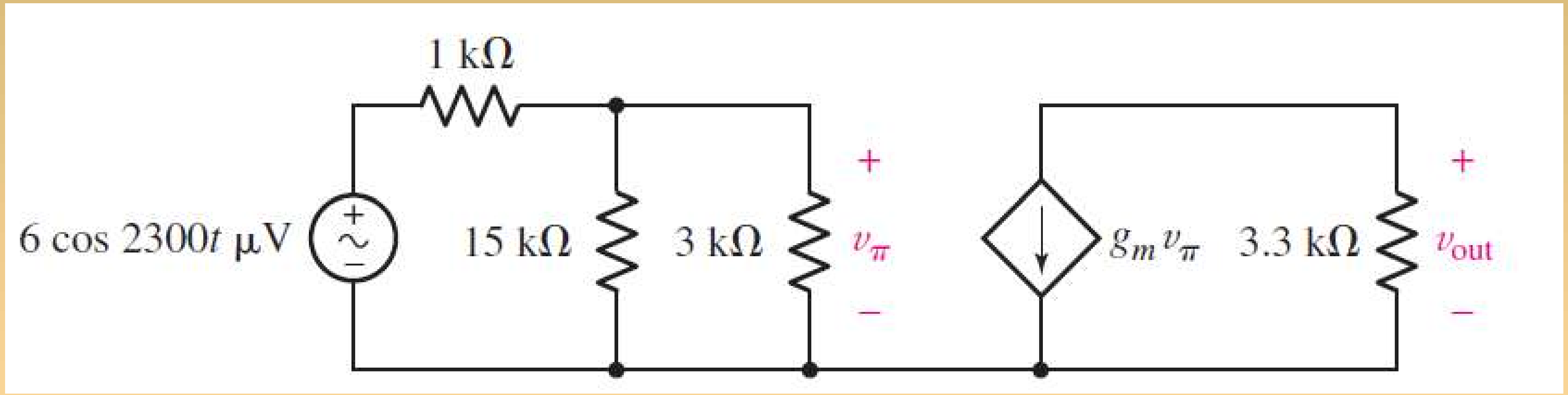
In the circuit, find i_1, i_2, and v_3.

Problem - 11



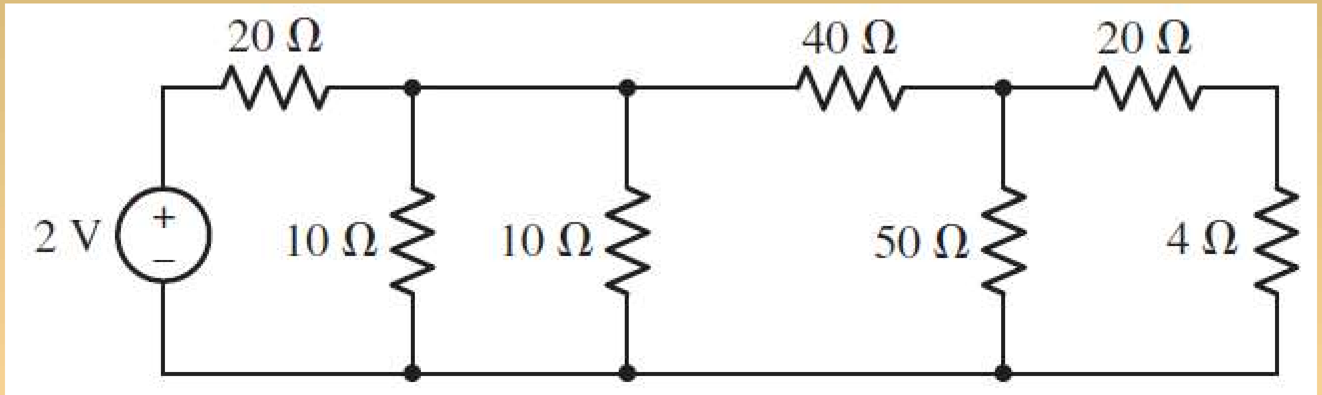
Determine the value of v_x as labeled in the circuit.

Problem - 12



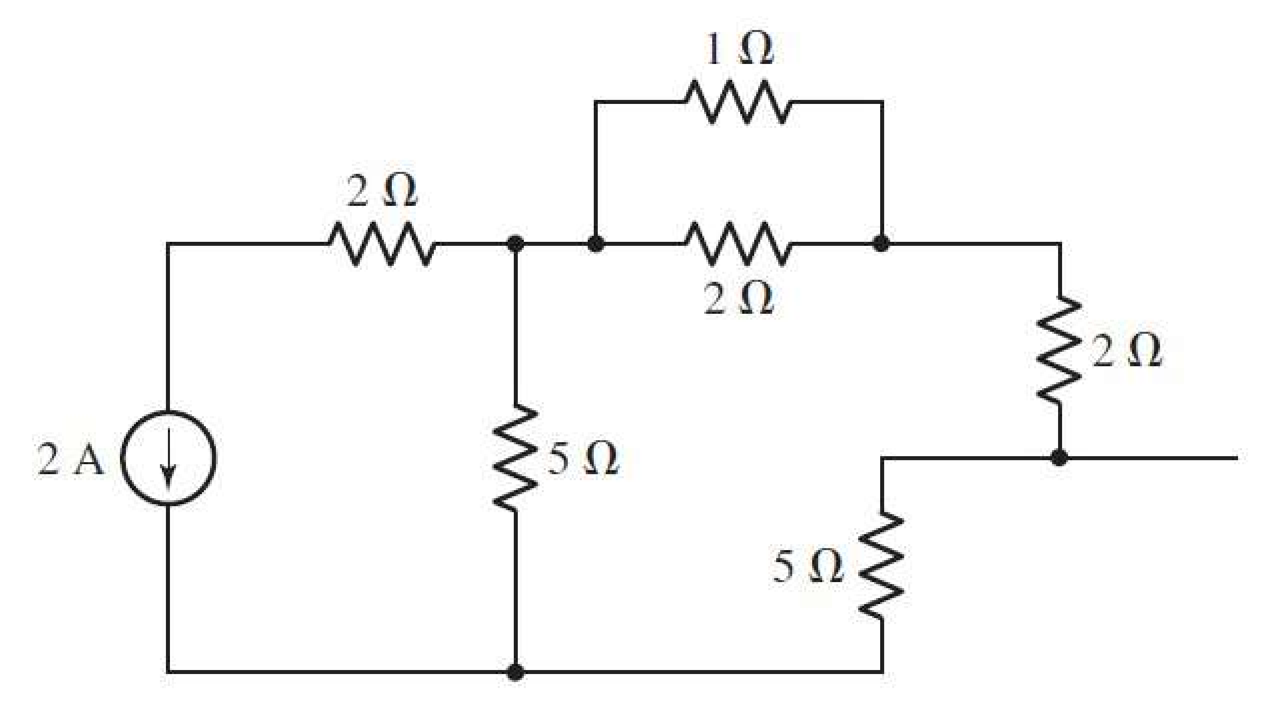
The circuit is routinely employed to model the midfrequency operation of a bipolar junction transistor–based amplifier. Calculate the amplifier output v_{out} if the transconductance g_m is equal to 322 mS.

Problem - 13



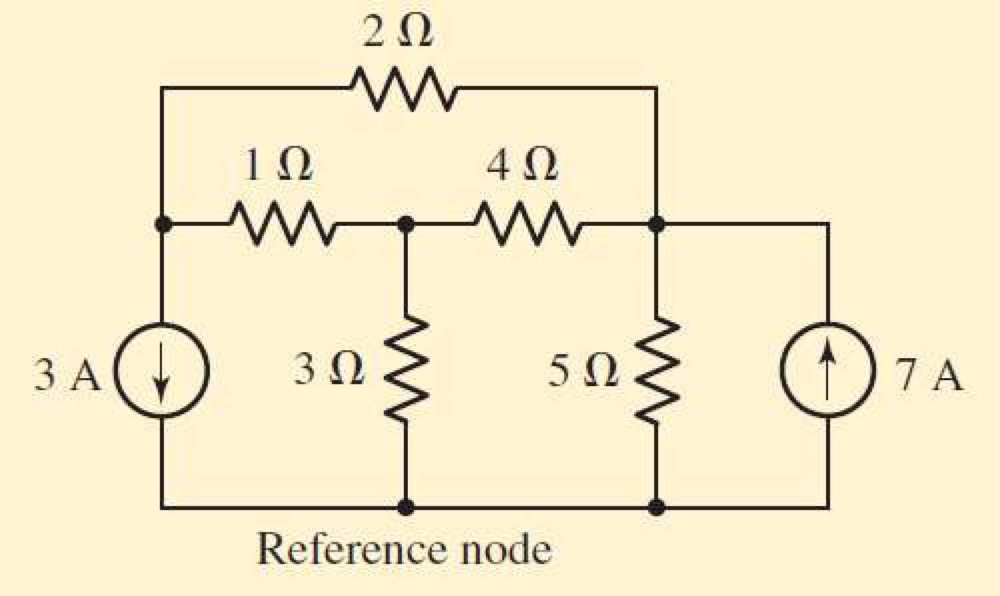
With regard to the circuit, compute (a) the voltage across the two 10 Ohm resistors; (b) the power dissipated by the 4 Ohm resistor.

Problem - 14



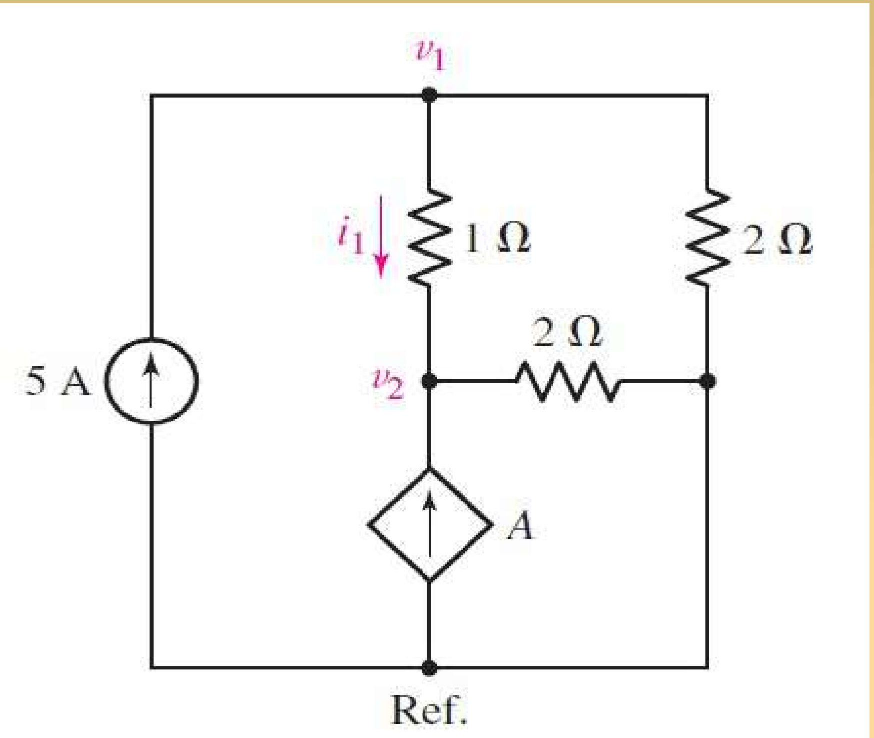
In the given circuit, (a) calculate the current flowing through each resistor and (b) determine the voltage across the current source

Problem - 15



For the circuit, compute the voltage across each current source.

Problem - 16

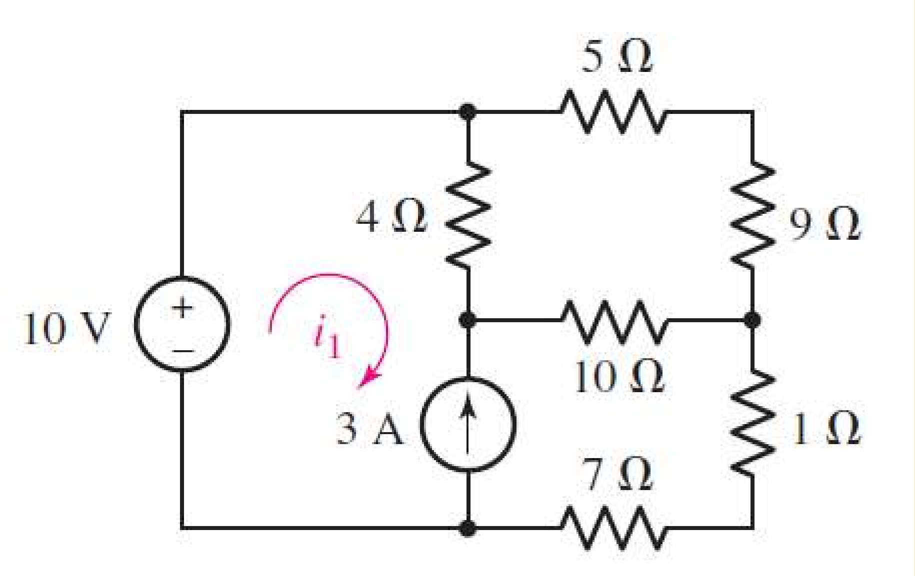


For the circuit, determine the nodal voltage v_1 if A is (a) $2i_1$; (b) $2v_1$.

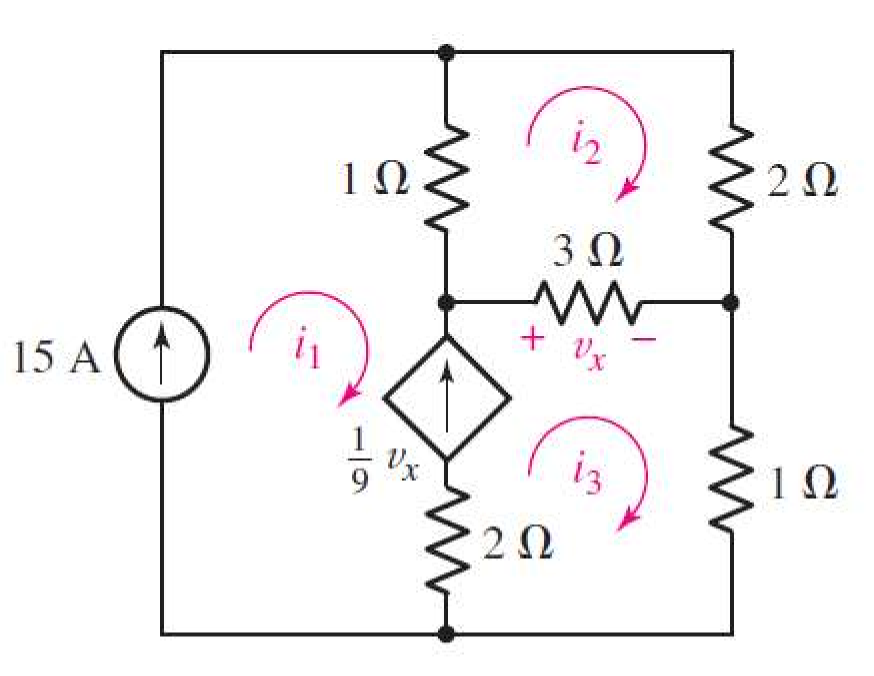
Basic nodal and mesh analysis and some useful circuit analysis techniques

Problem - 1

Determine the current i_1 in the circuit.

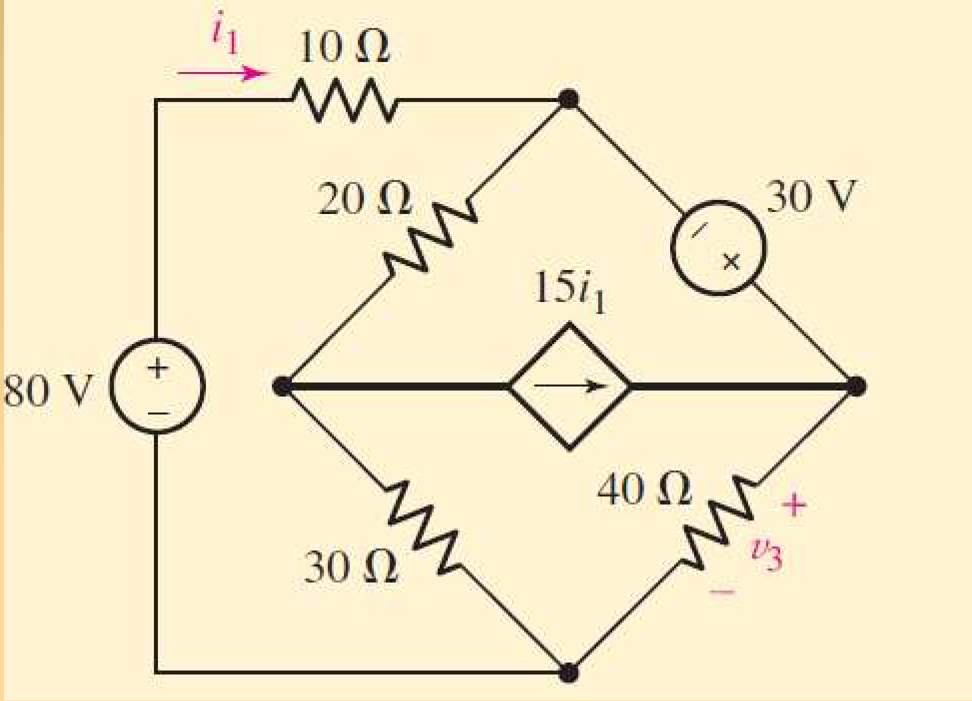


Problem - 2



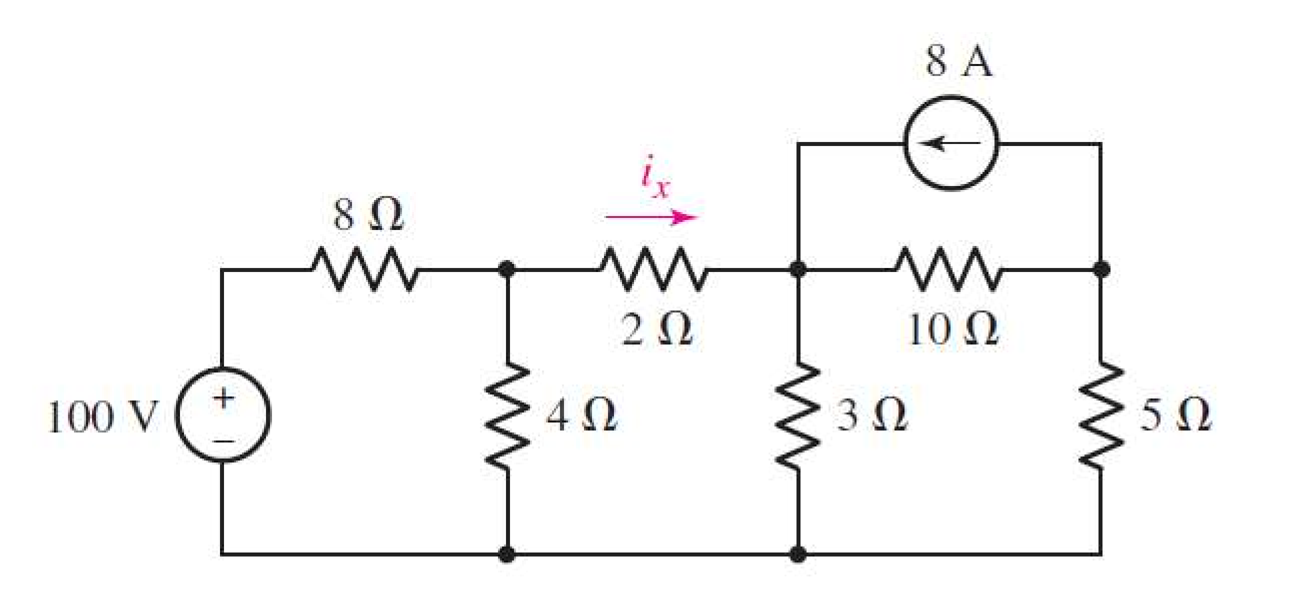
Evaluate the three unknown currents in the circuit.

Problem - 3



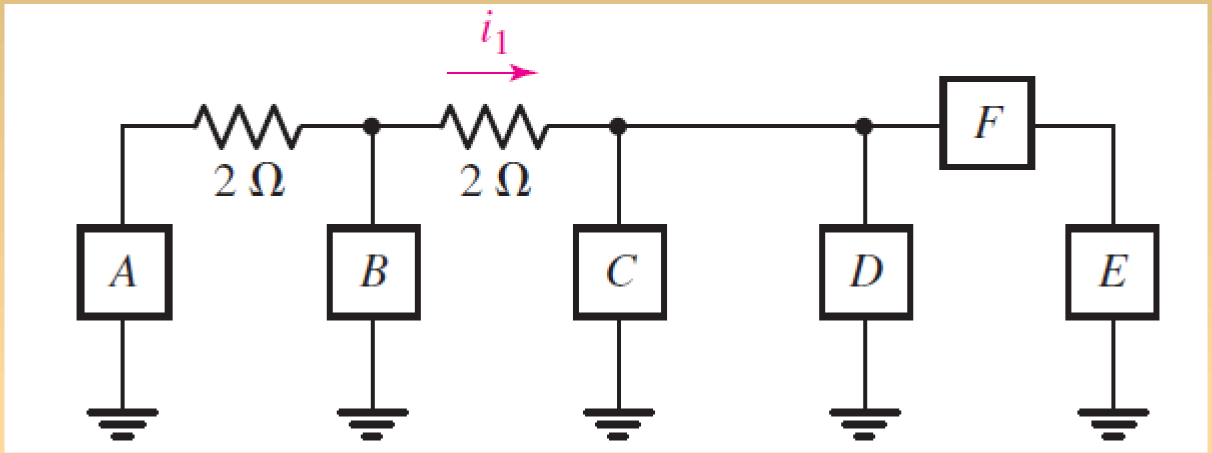
Determine v_3 in the circuit.

Problem - 4



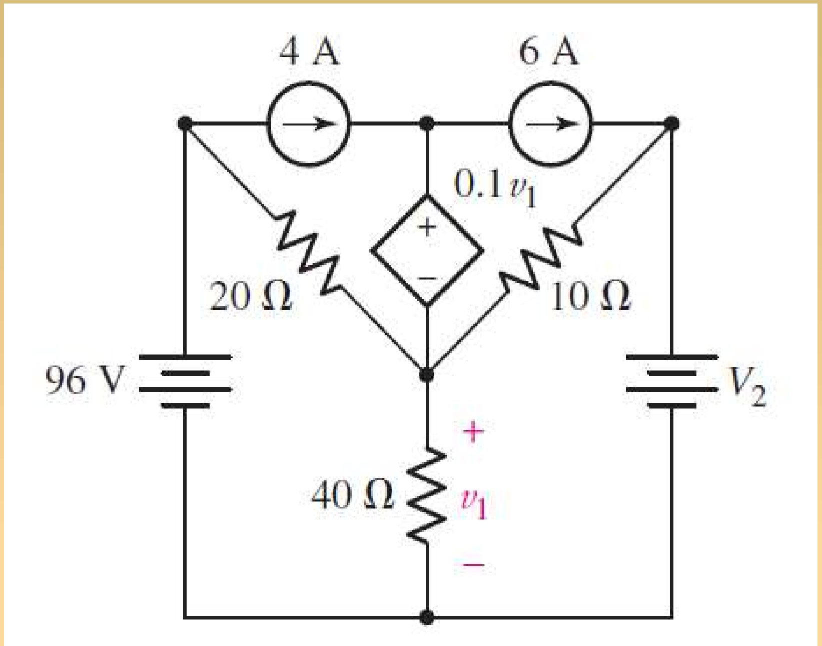
Determine i_x in the given circuit.

Problem - 5



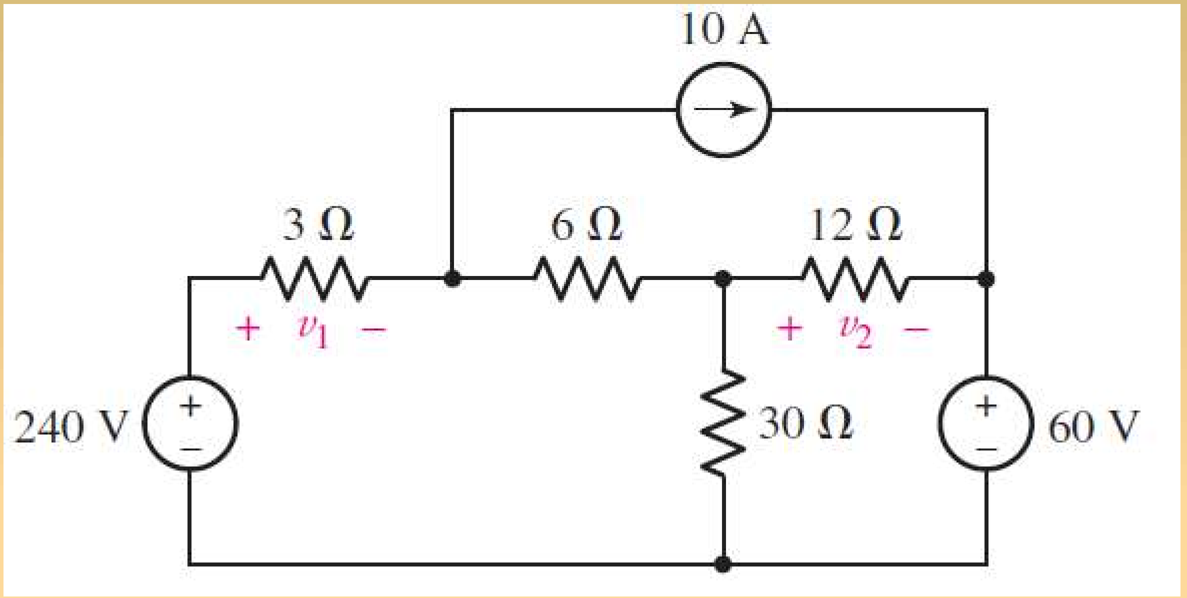
Consider the circuit and employ either nodal or mesh analysis as a design tool to obtain a value of 200 mA for i_1, if elements A, B, C, D, E, and F must be either current or voltage sources with nonzero values.

Problem - 6



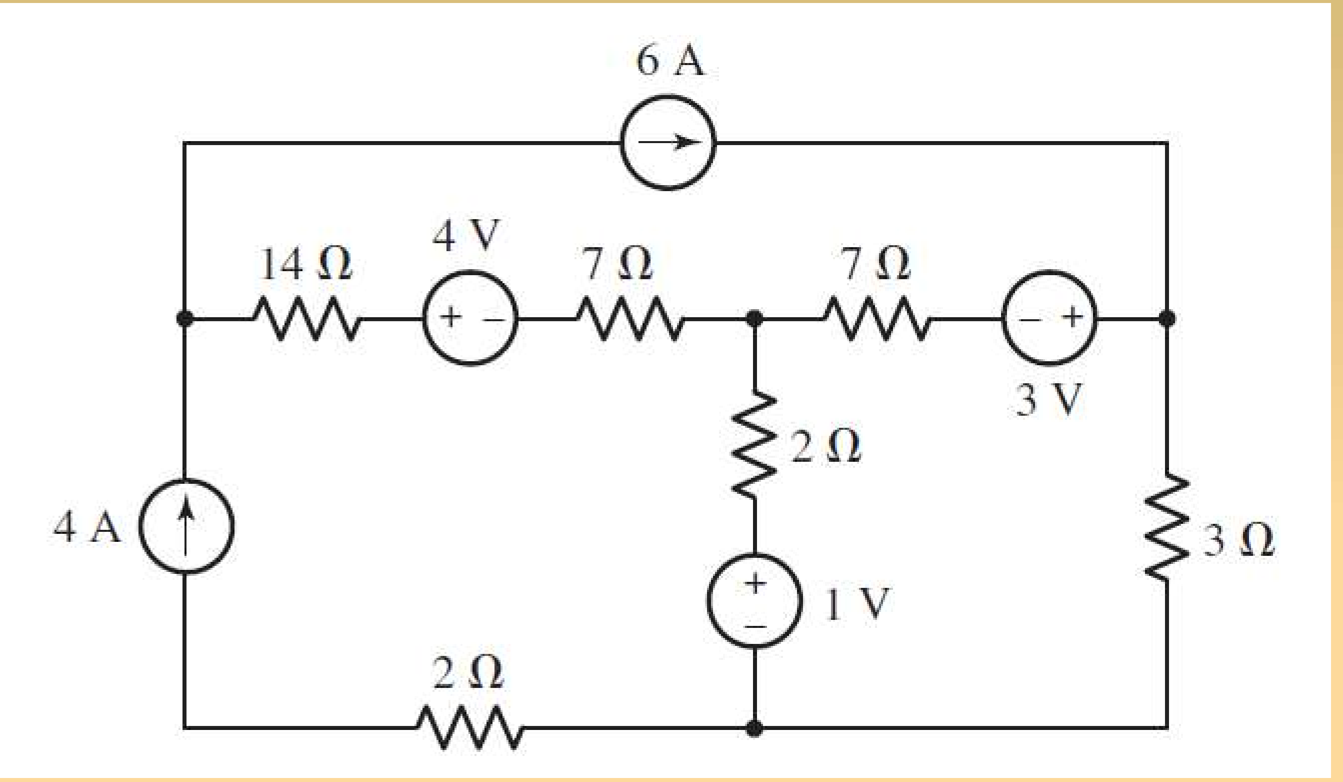
Consider the five-source circuit and determine the total number of simultaneous equations that must be solved in order to determine v_1 using (a) nodal analysis; (b) mesh analysis. (c) Which method is preferred, and does it depend on which side of the 40 Ohm resistor is chosen as the reference node? Explain your answer.

Problem - 7



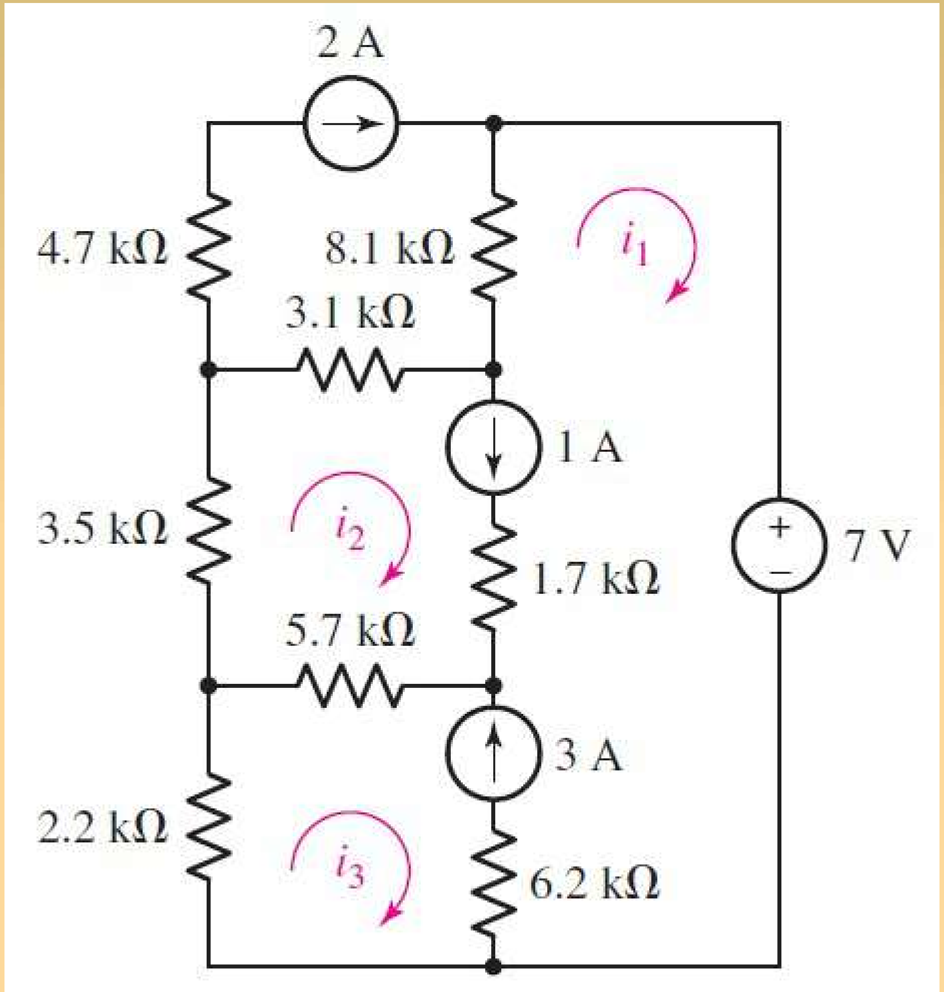
The circuit contains three sources. (a) As presently drawn, would nodal or mesh analysis result in fewer equations to determine the voltages v_1 and v_2? Explain. (b) If the voltage sources were replaced with current sources, and the current source replaced with a voltage source, would your answer to part (a) change? Explain.

Problem - 8



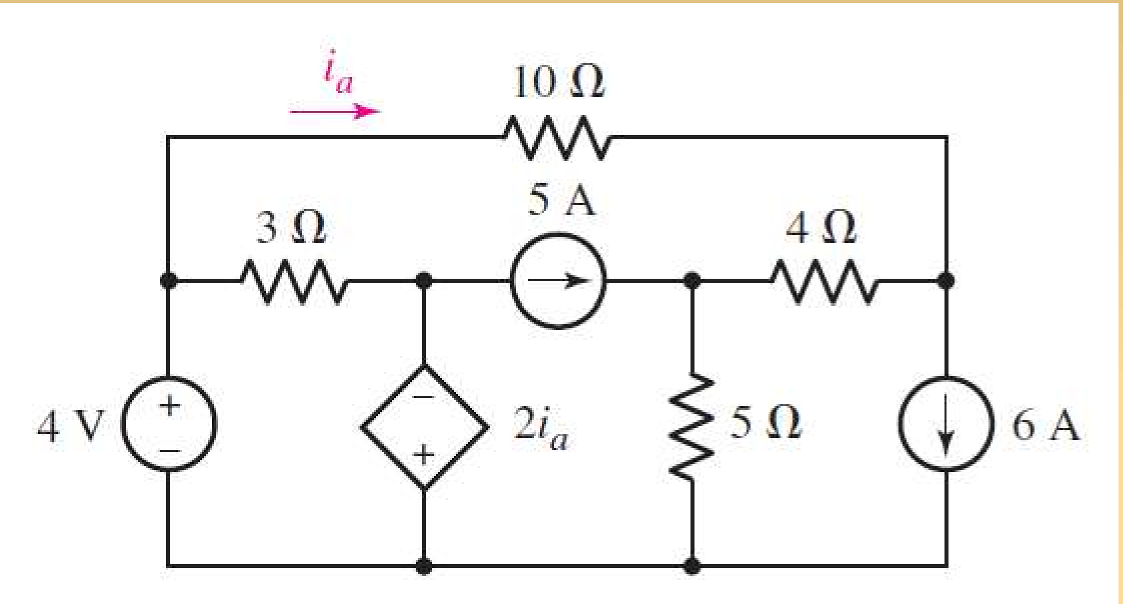
Obtain a numerical value for the power supplied by the 1 V source.

Problem - 9



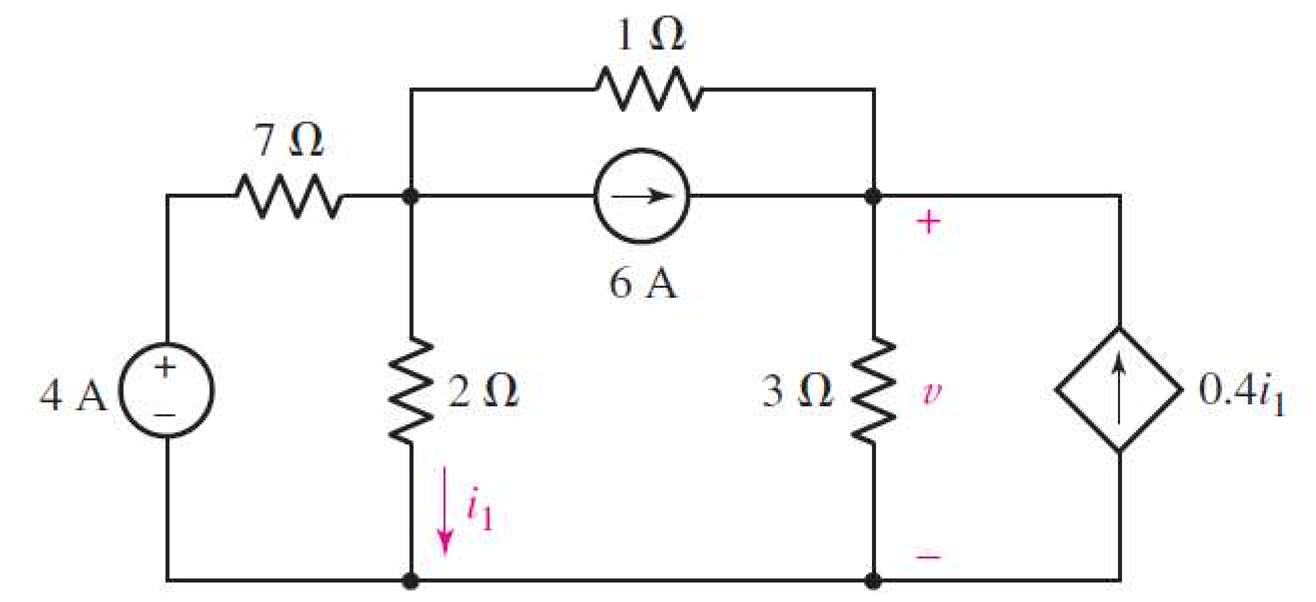
Calculate the three mesh currents labeled in the circuit diagram.

Problem - 10



Determine the power absorbed by the 10 Ohm resistor.

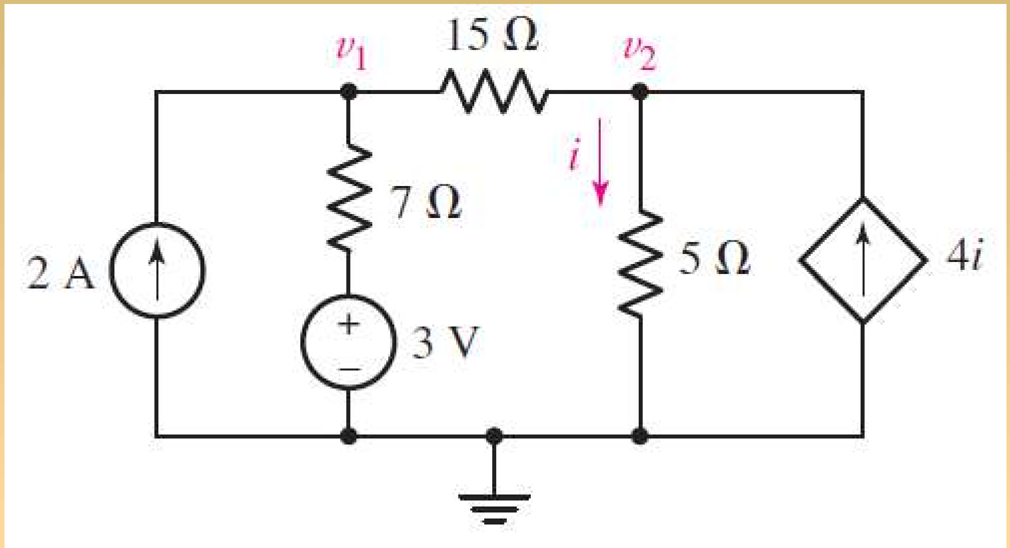
Problem - 11



(a) Employ superposition to determine the individual contribution from each independent source to the voltage v as labeled in the circuit.

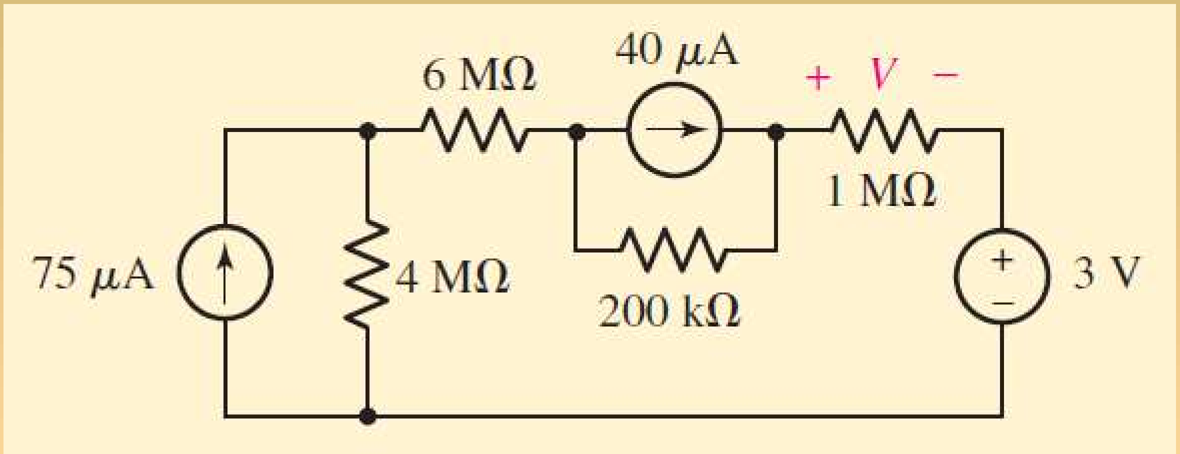
(b) Compute the power absorbed by the 2 Ohm resistor.

Problem - 12



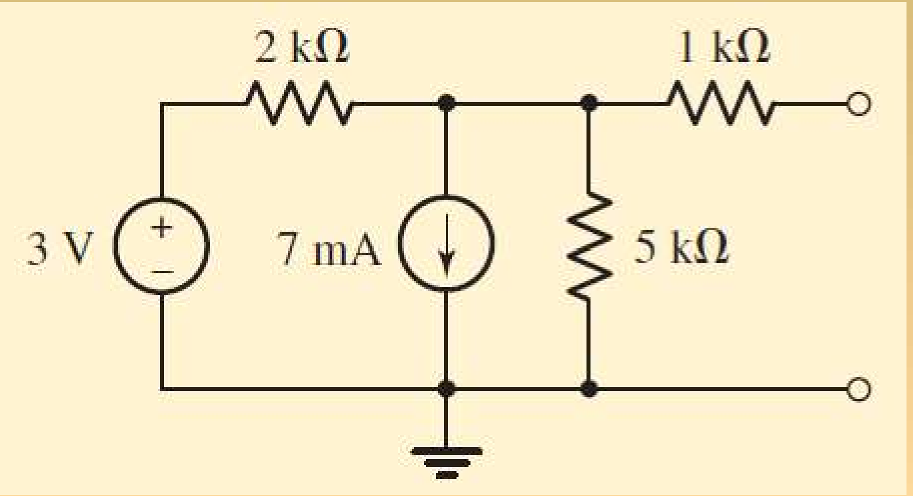
For the circuit, use superposition to obtain the voltage across each current source.

Problem - 13



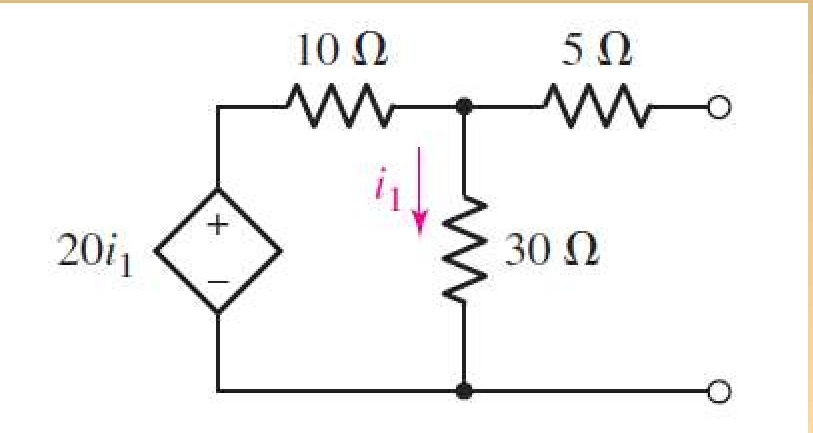
For the circuit, compute the voltage V across the 1 M Ohm resistor using repeated source transformations.

Problem - 14



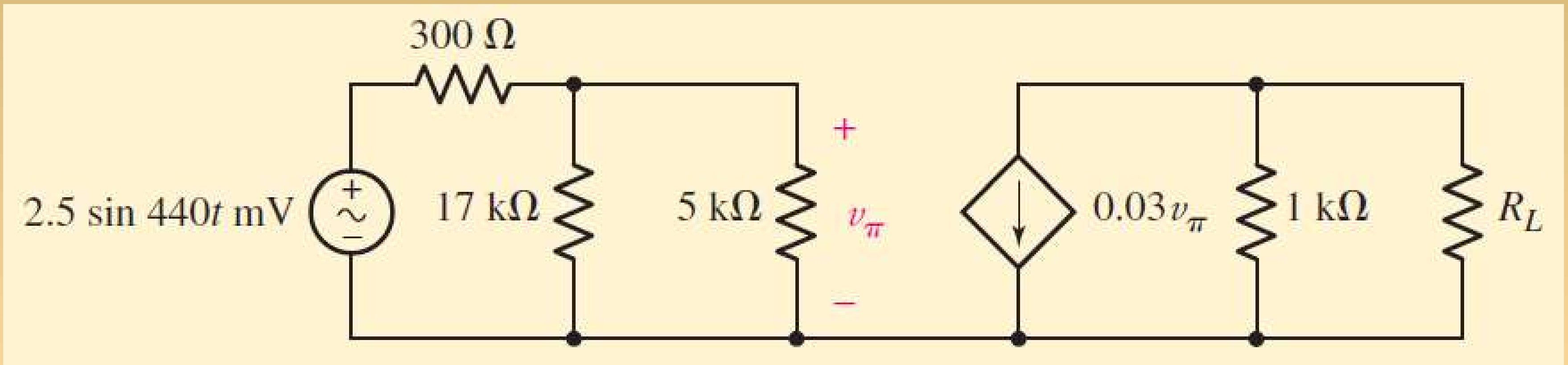
Determine the Thévenin and Norton equivalents of the circuit.

Problem - 15



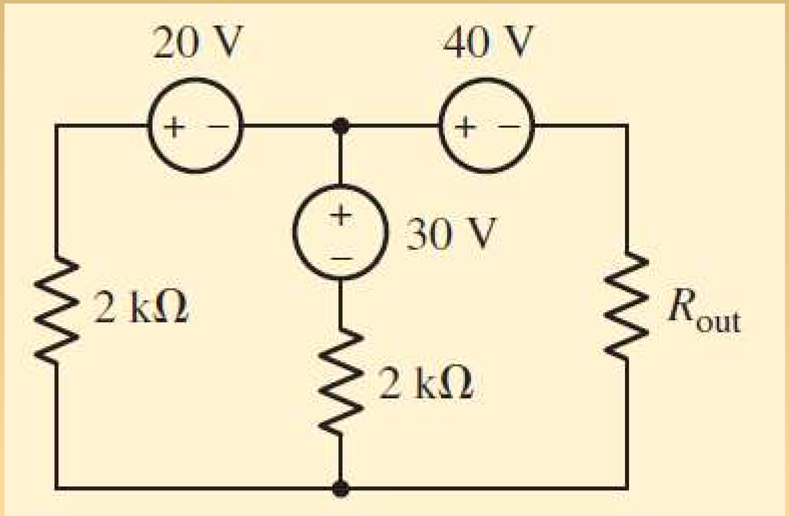
Find the Thévenin equivalent for the network.

Problem - 16



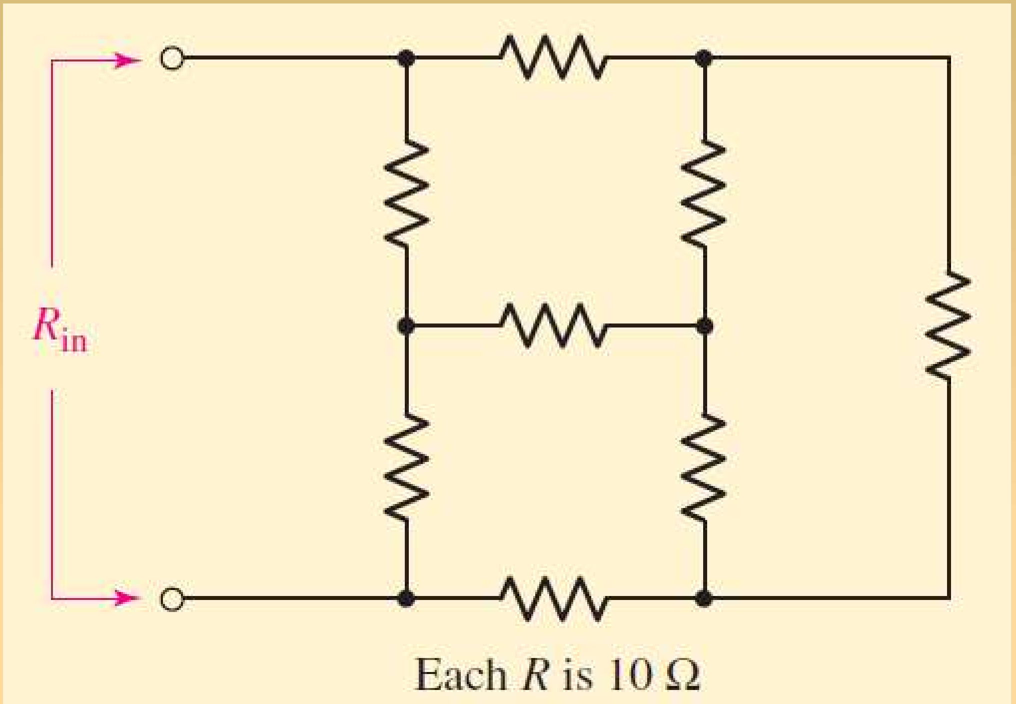
The circuit is a model for the common-emitter bipolar junction transistor amplifier. Choose a load resistance so that maximum power is transferred to it from the amplifier, and calculate the actual power absorbed.

Problem - 17



(a) If R_{out} =3 k Ohm, find the power delivered to it. (b) What is the maximum power that can be delivered to any R_{out}? (c) What two different values of R_{out} will have exactly 20 mW delivered to them?

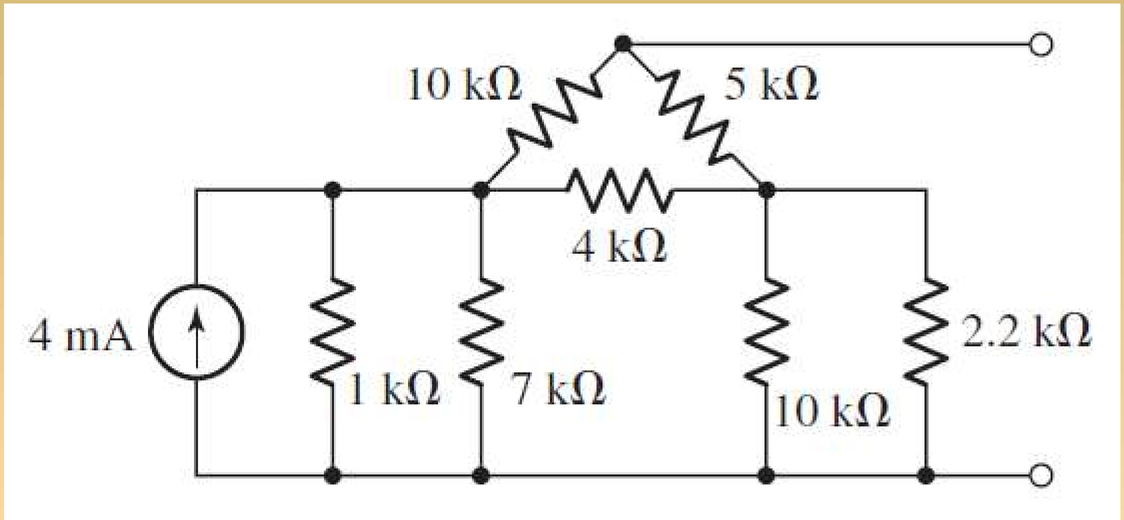
Problem - 18



Use the technique of Y-Δ conversion to find the Thévenin equivalent resistance of the circuit.

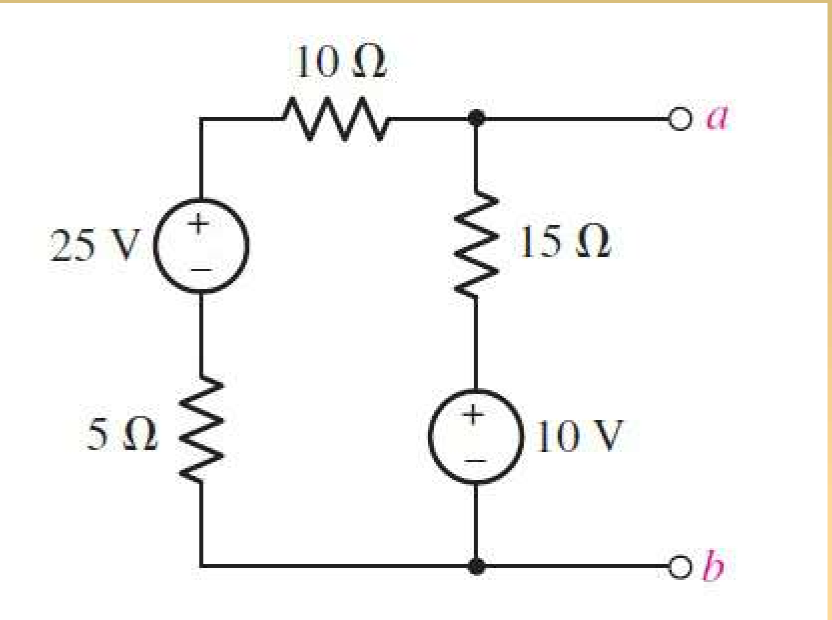
Capacitors, Inductors, and circuit analysis techniques in s-domain

Problem - 1



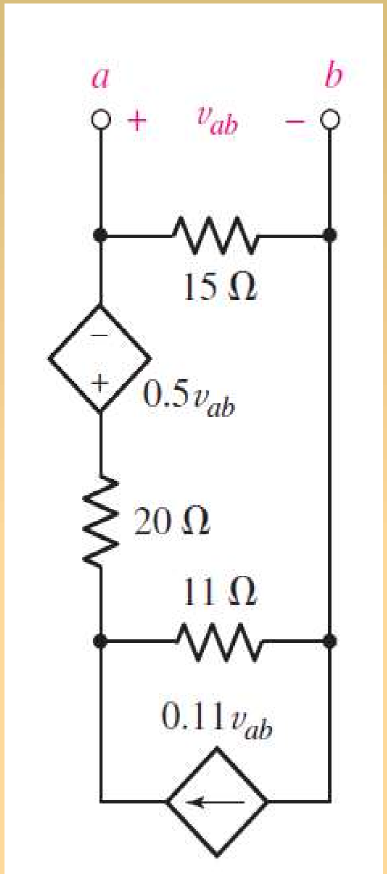
Determine the power absorbed by a resistor connected between the open terminal of the circuit if it has a value of (a) 1 Ohm; (b) 100 Ohm; (c) 2.65 k-Ohm; (d) 1.13 M-Ohm.

Problem - 2



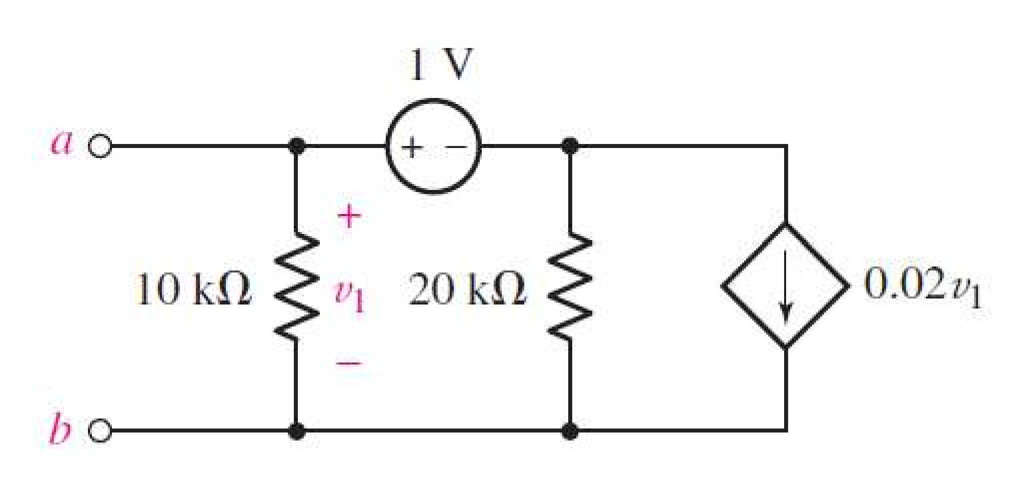
It is known that a load resistor of some type will be connected between terminals 'a' and 'b' of the network. (a) Change the value of the 25 V source such that both voltage sources contribute equally to the power delivered to the load resistor, assuming its value is chosen such that it absorbs maximum power. (b) Calculate the value of the load resistor.

Problem - 3



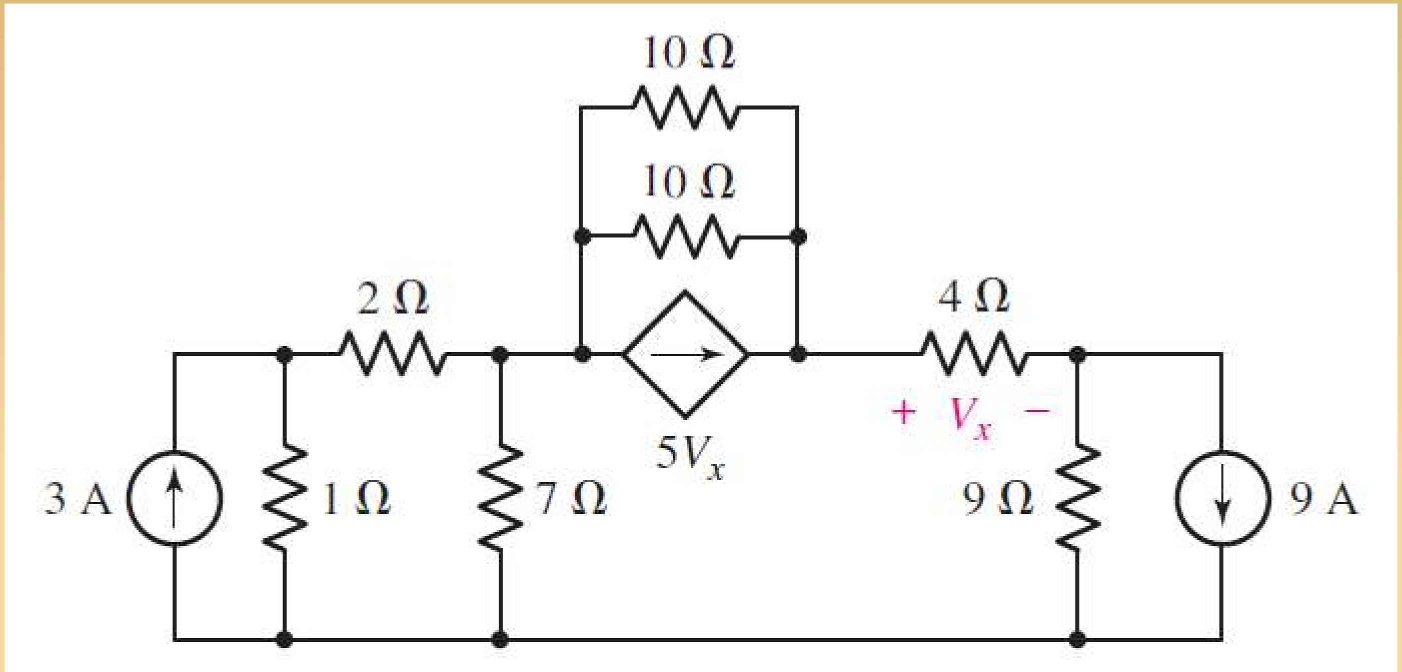
Determine the Thévenin and Norton equivalents of the circuit as seen by an unspecified element connected between terminals 'a' and 'b'.

Problem - 4



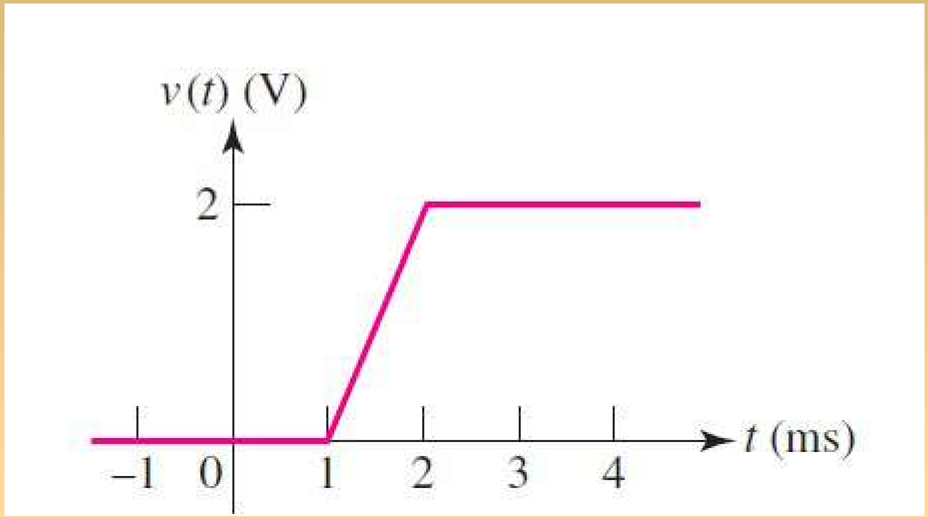
Determine the power dissipated by (a) a 1 k-Ohm resistor connected between 'a' and 'b'; (b) a 4.7 k-Ohm resistor connected between 'a' and 'b'; (c) a 10.54 k-Ohm resistor connected between 'a' and 'b'.

Problem - 5



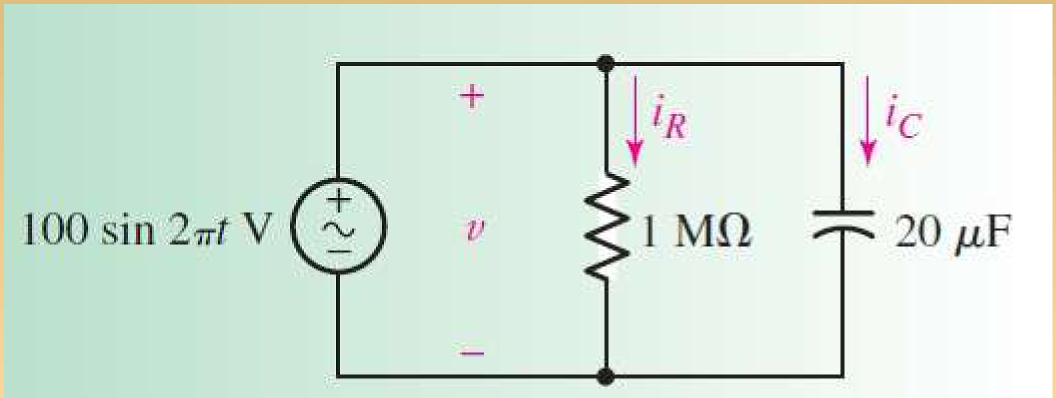
Make use of source transformations to first convert all three sources to voltage sources, then simplify the circuit as much as possible and calculate the voltage V_x which appears across the 4 Ohm resistor. Be sure to draw and label your simplified circuit.

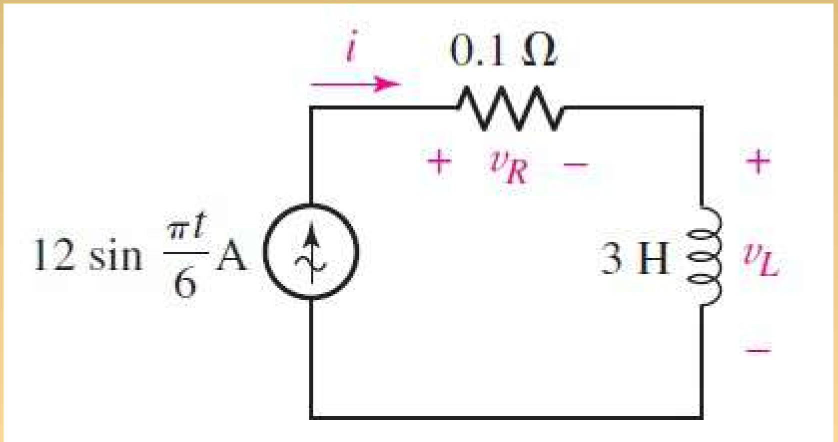
Problem - 6



(a) Determine the current through a 100 pF capacitor if its voltage as a function of time is given by the above figure.
(b) Calculate the energy stored in a 1000 μF capacitor at $t = 50\mu s$ if the voltage across it is $1.5 \cos 10^5 t$ volts.

Problem - 7

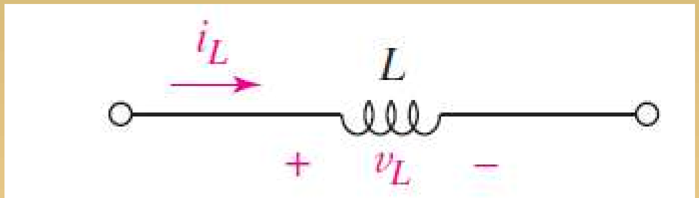




(a) For the circuit in the left, find the maximum energy stored in the capacitor and the energy dissipated in the resistor over the interval $0 < t < 0.5$ s.

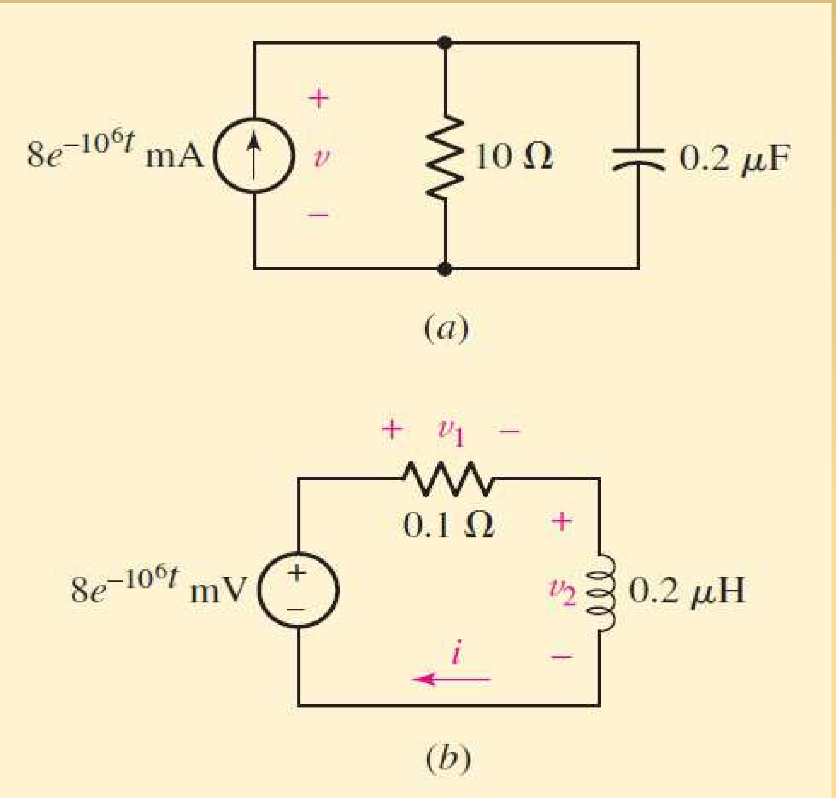
(b) For the circuit in the right, find the maximum energy stored in the inductor and calculate how much energy is dissipated in the resistor in the time during which the energy is being stored in, and then recovered from, the inductor.

Problem - 8



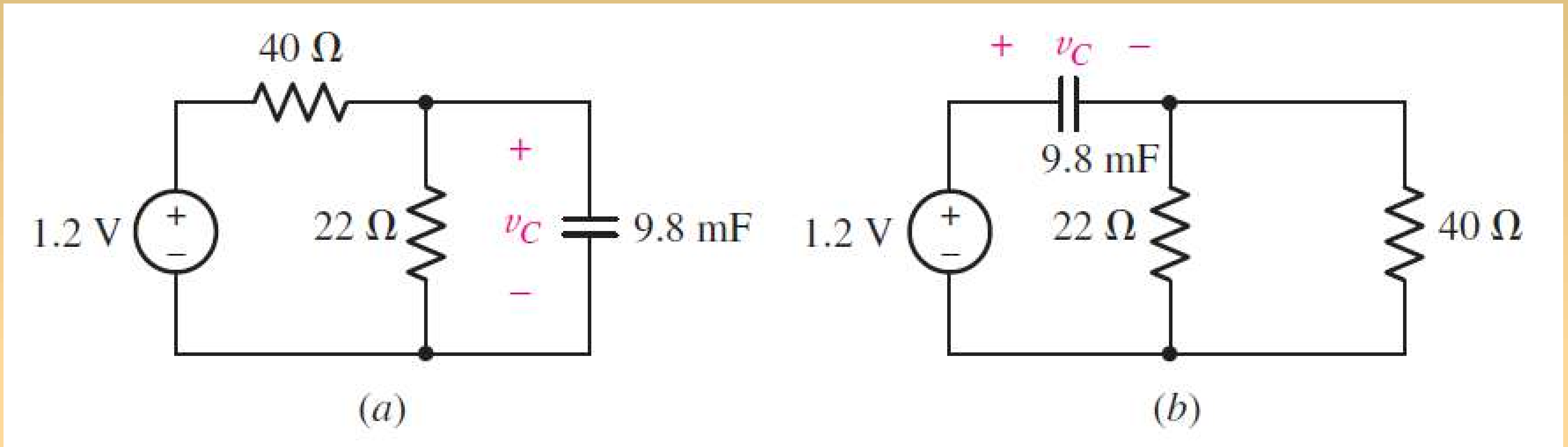
Let L = 25 mH for the inductor. (a) Find v_L at t = 12 ms if $i_L = 10te^{-100t}$ A. (b) Find i_L at t = 0.1 s if $v_L = 6e^{-12t}$ V and $i_L(0)$ = 10 A. If $i_L = 8(1 - e^{-40t})$ mA, find (c) the power being delivered to the inductor at t = 50 ms and (d) the energy stored in the inductor at t = 40 ms.

Problem - 9



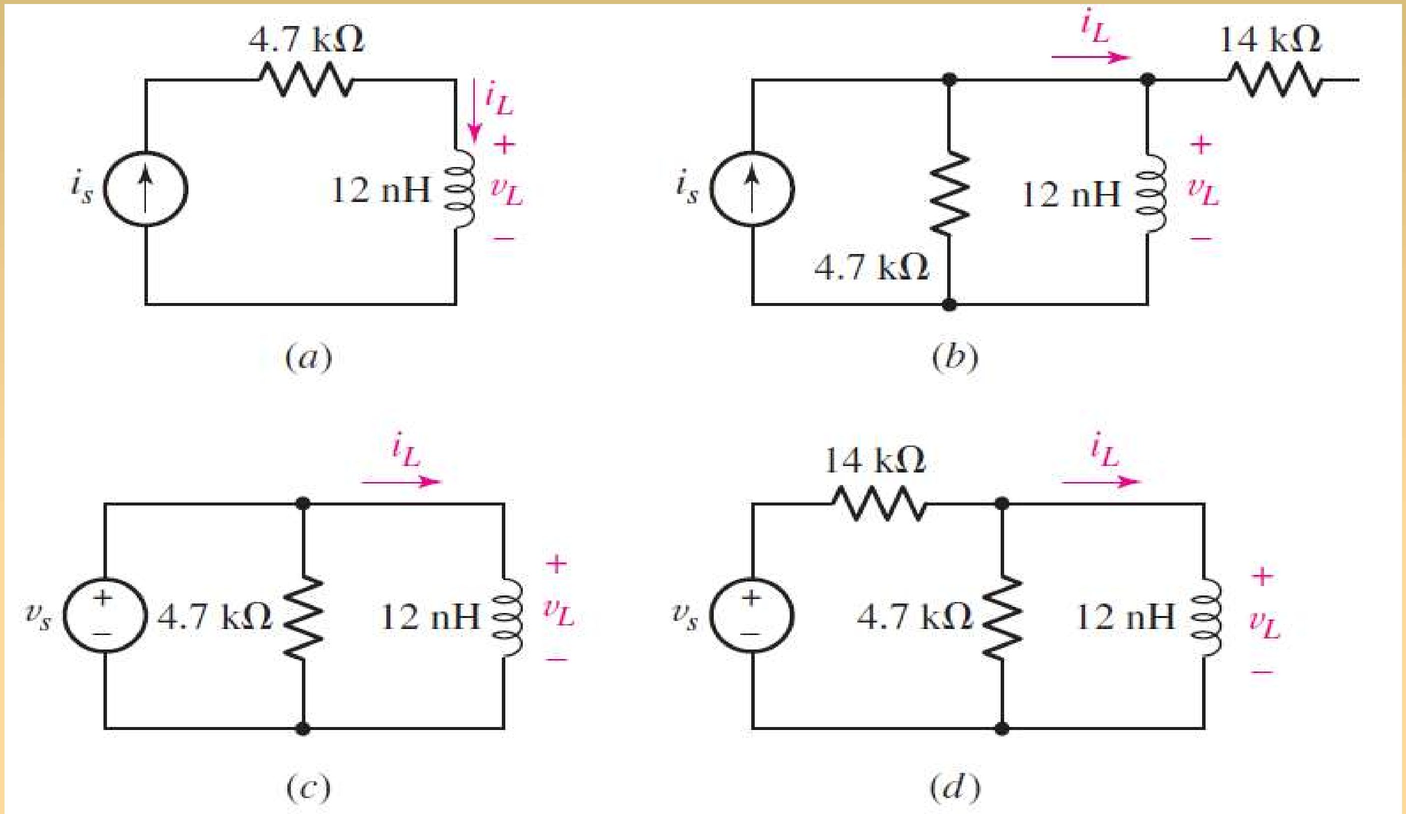
Write the single nodal equation for the circuit of (a) and show, by direct substitution, that $v = -80\exp(-10^6 t)$ mV is a solution. Knowing this, find (a) v_1; (b) v_2; and (c) i for the circuit of (b).

Problem - 10



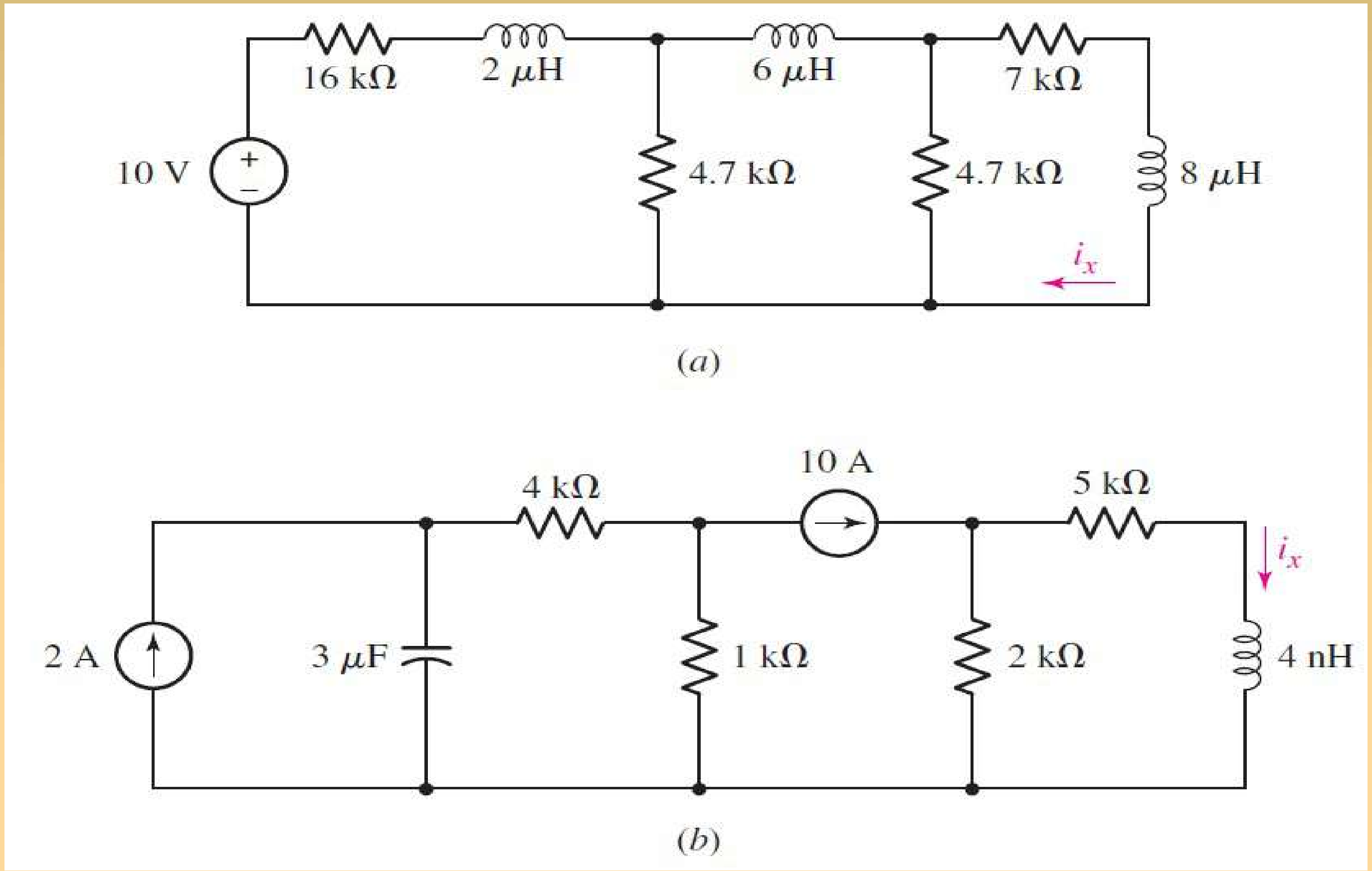
Calculate the power dissipated in the 40 Ohm resistor and the voltage labeled v_c in each of the circuits.

Problem - 11



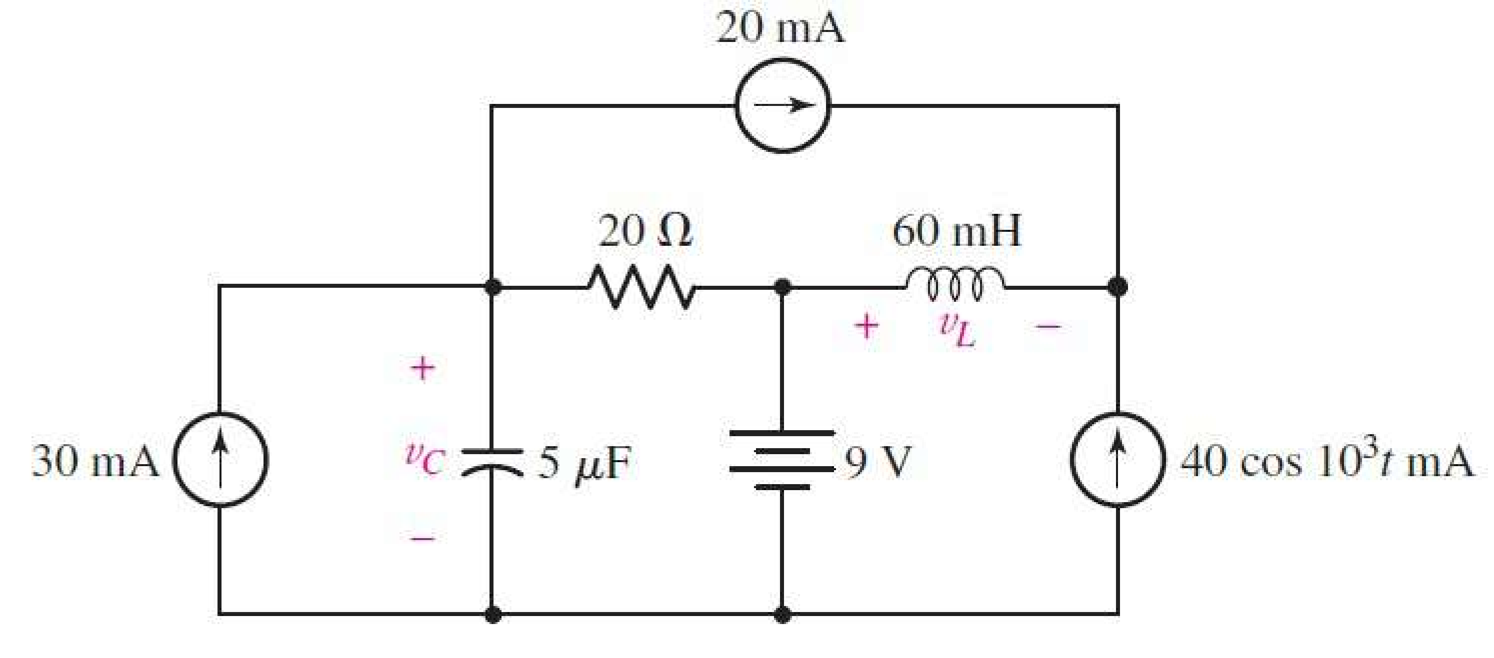
Calculate v_L and i_L for each of the circuits if i_s = 1 mA and v_s = 2.1 V.

Problem - 12



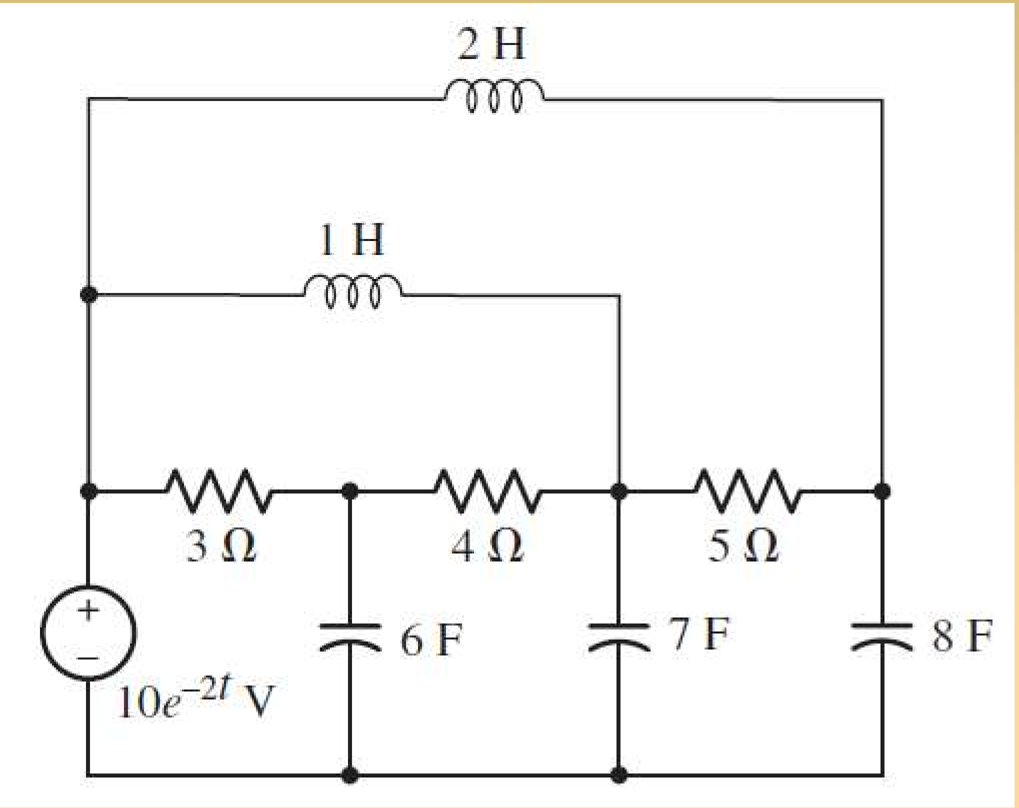
Making the assumption that both the circuits have been connected for a very long time, determine the value for each current labeled i_x.

Problem - 13



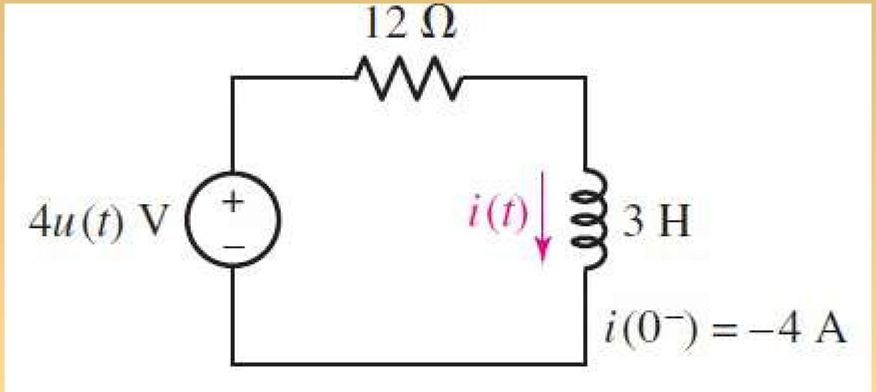
If it is assumed that all the sources in the circuit have been connected and operating for a very long time, find $v_C(t)$ and $v_L(t)$.

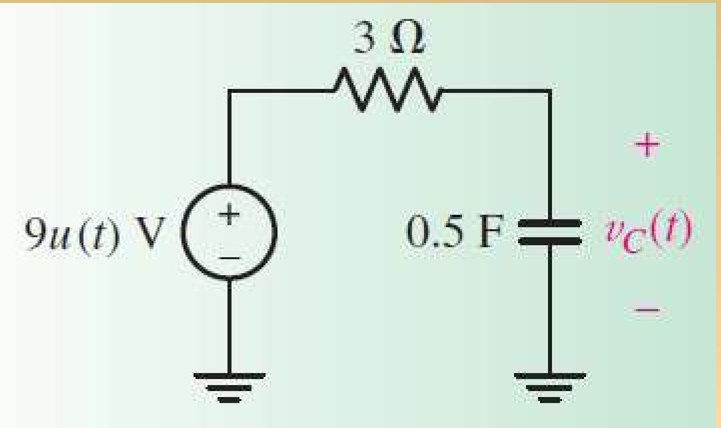
Problem - 14



Draw the exact dual of the circuit. Keep it neat!

Problem - 15

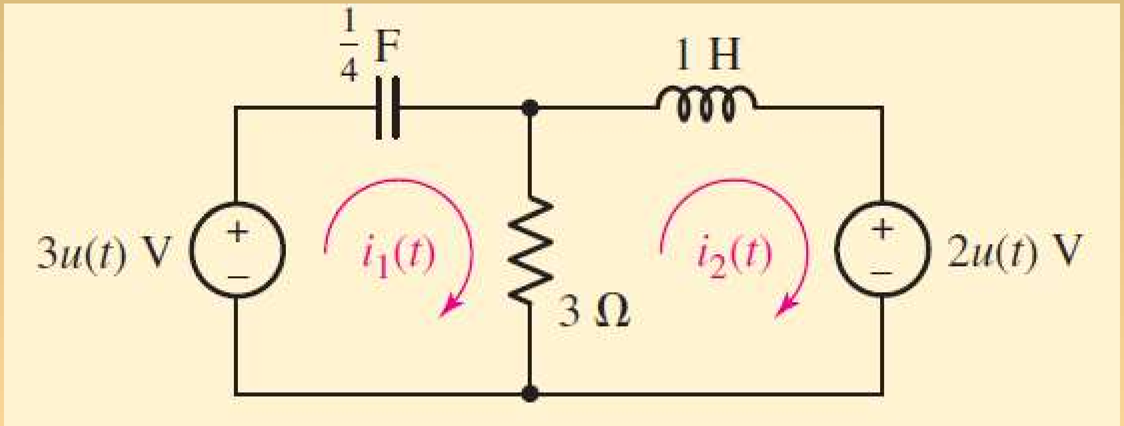




(a) Determine the current i(t) in the circuit (given in left) analysing in the s-domain.

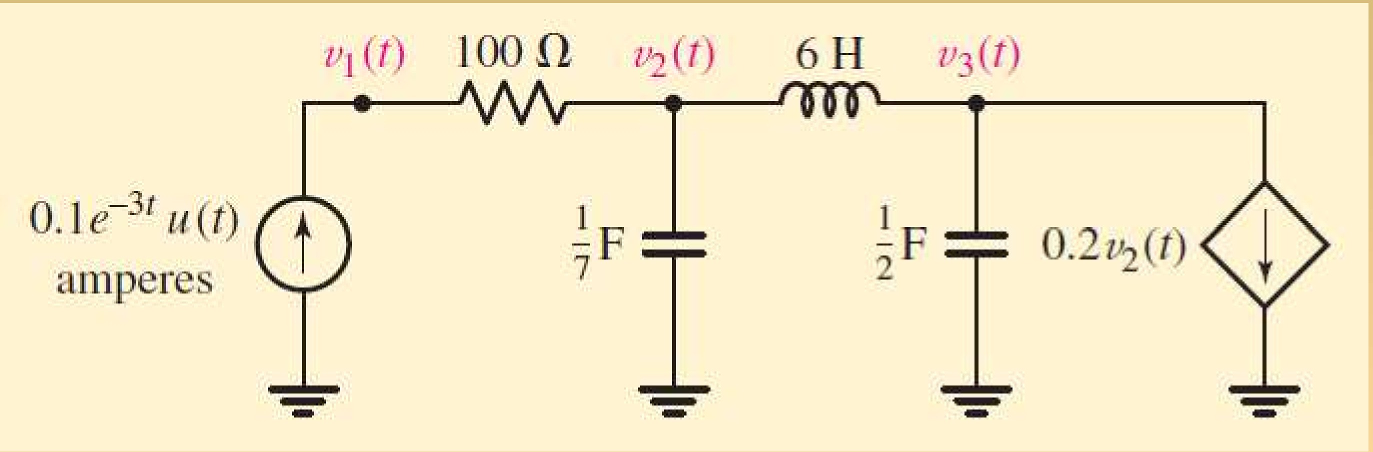
(b) Determine $v_c(t)$ in the circuit (right-sided), given an initial voltage $v_c(0^-)=-2$ V. Analyse in the s-domain.

Problem - 16



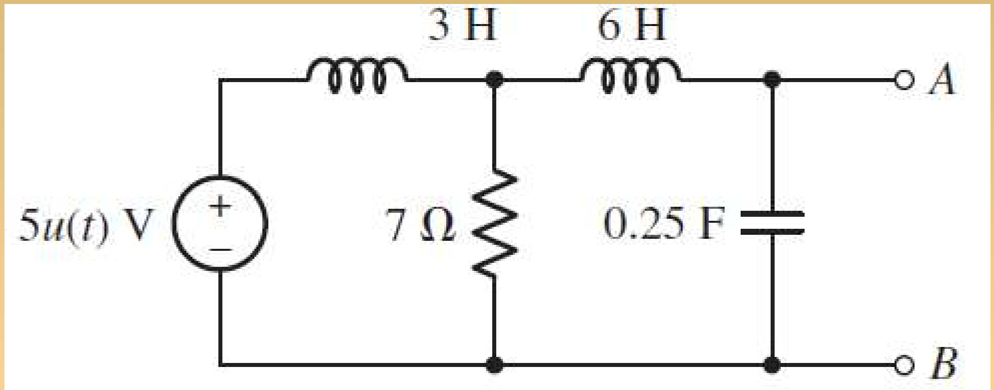
Find the mesh currents i_1 and i_2 in the circuit. You may assume no energy is stored in the circuit at $t = 0^-$. Analyse in s-domain.

Problem - 17



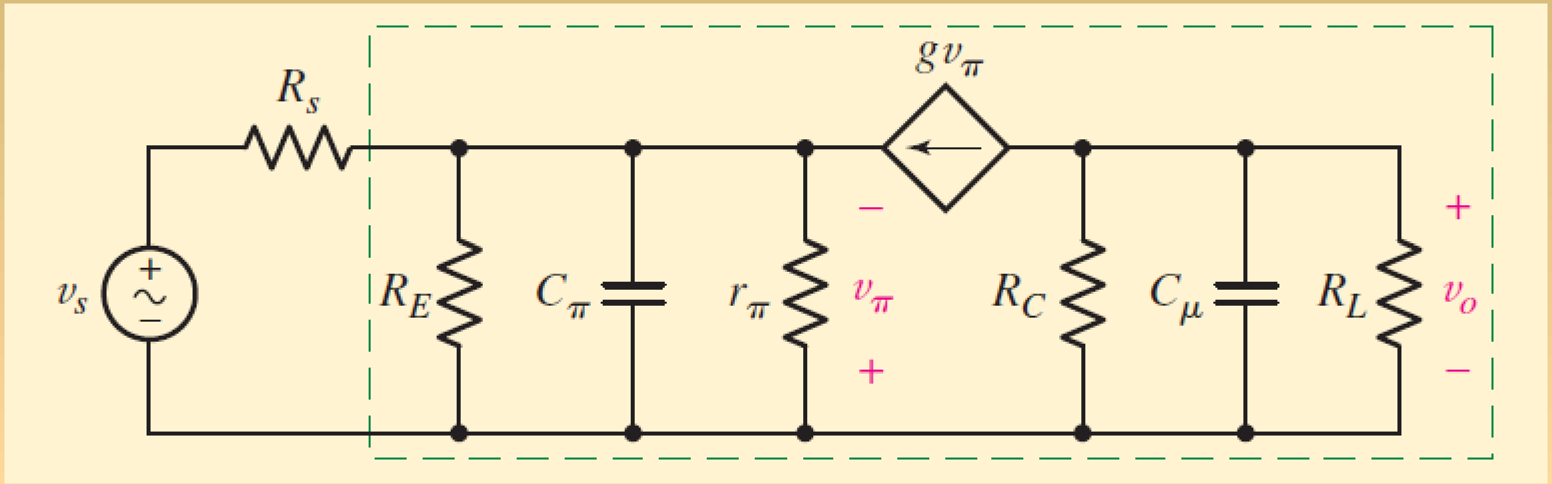
Use nodal analysis in the s-domain to determine the voltages v_1, v_2, and v_3 in the circuit. No energy is stored in the circuit at $t = 0^-$.

Problem - 18



Using the method of source transformation, reduce the circuit to a single s-domain current source in parallel with a single impedance.

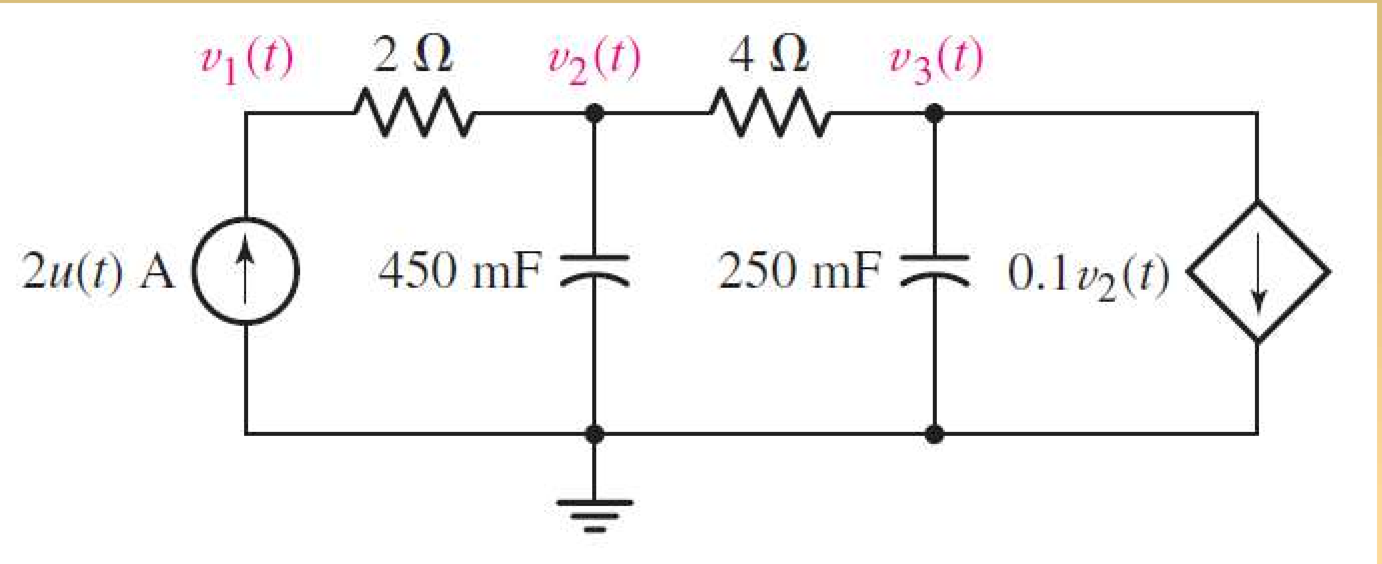
Problem - 19



Find the s-domain Thévenin equivalent of the highlighted network.

Circuit analysis in the s-domain

Problem - 1



For the given circuit,

(a) draw the corresponding s-domain circuit;

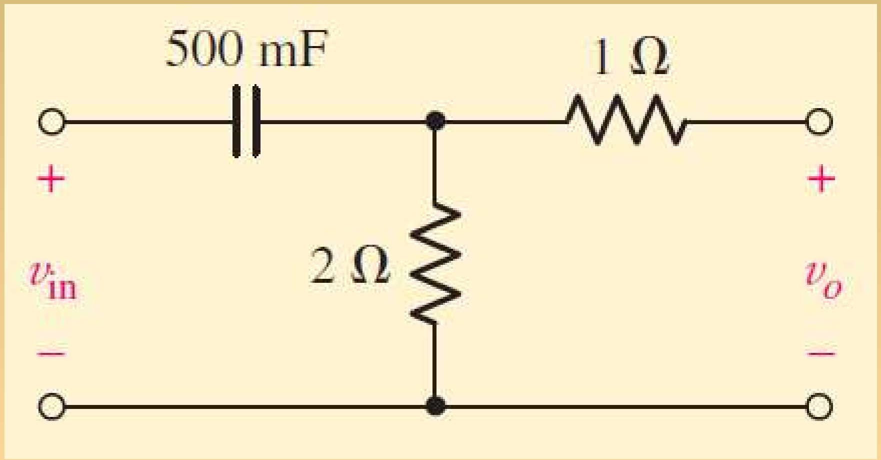
(b) solve for $v_1(t)$, $v_2(t)$, and $v_3(t)$.

Problem - 2

(a) Apply a unit-step function, $x(t) = u(t)$, as the input to a system whose impulse response is $h(t) = u(t) - 2u(t - 1) + u(t - 2)$, and determine the corresponding output $y(t) = x(t)*h(t)$.

(b) Repeat the above problem by performing the convolution in the s-domain.

Problem - 3



(a) Determine the impulse response of the circuit and use this to compute the forced response $v_o(t)$ if the input $v_{in}(t) = 6e^{-t}u(t)$ V.

(b) use convolution to obtain $v_o(t)$ if $v_{in} = tu(t)$ V.

Problem - 4

(a) Sketch the admittance of the series combination of a 1 H inductor and a 3 Ohm resistor as a function of both $j\omega$ and σ.

(b) Sketch the magnitude of the impedance $Z(s) = 2 + 5s$ as a function of σ and $j\omega$.

Problem - 5

The parallel combination of 0.25 mH and 5 Ohm is in series with the parallel combination of 40 μF and 5 Ohm.

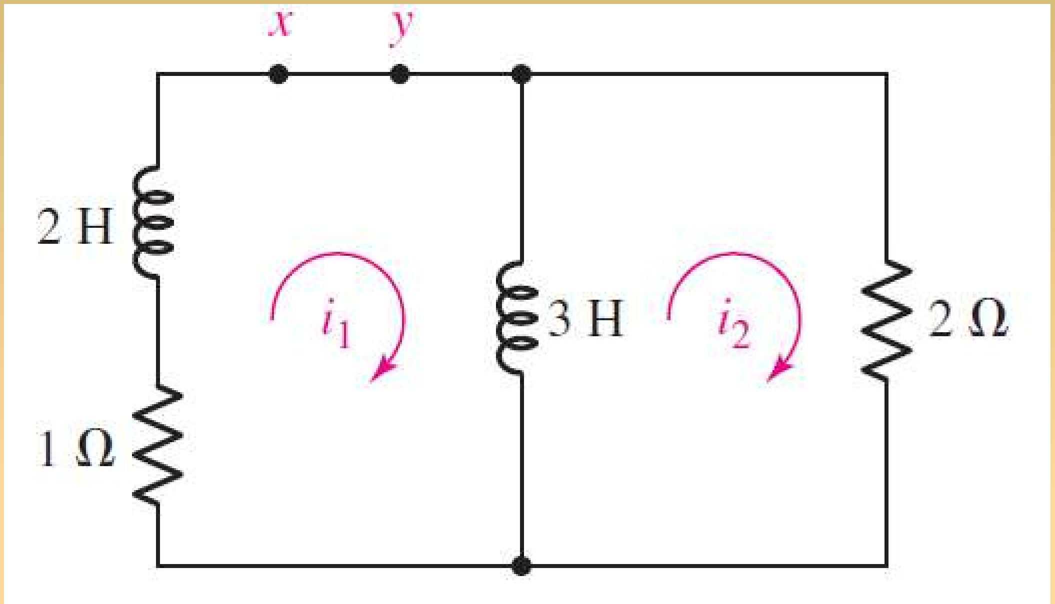
(a) Find $Z_{in}(s)$, the input impedance of the series combination.

(b) Specify all the zeros of $Z_{in}(s)$.

(c) Specify all the poles of $Z_{in}(s)$.

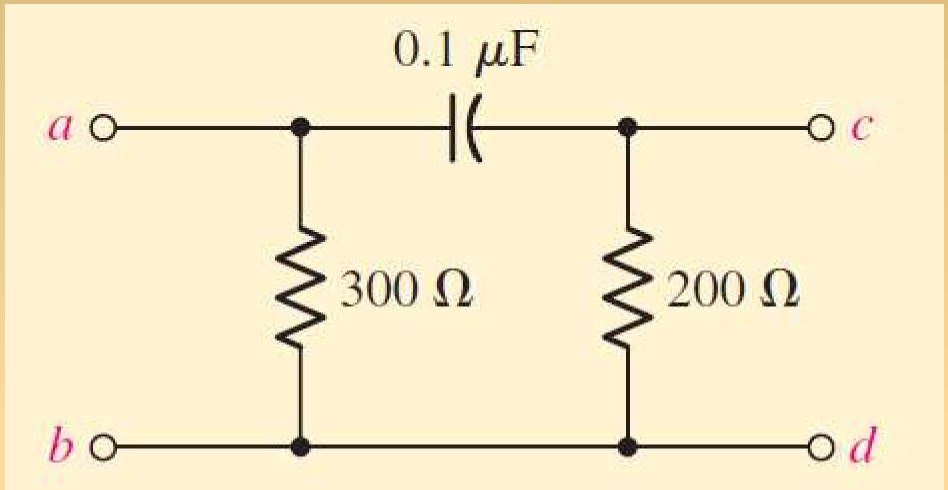
(d) Draw the pole-zero constellation.

Problem - 6



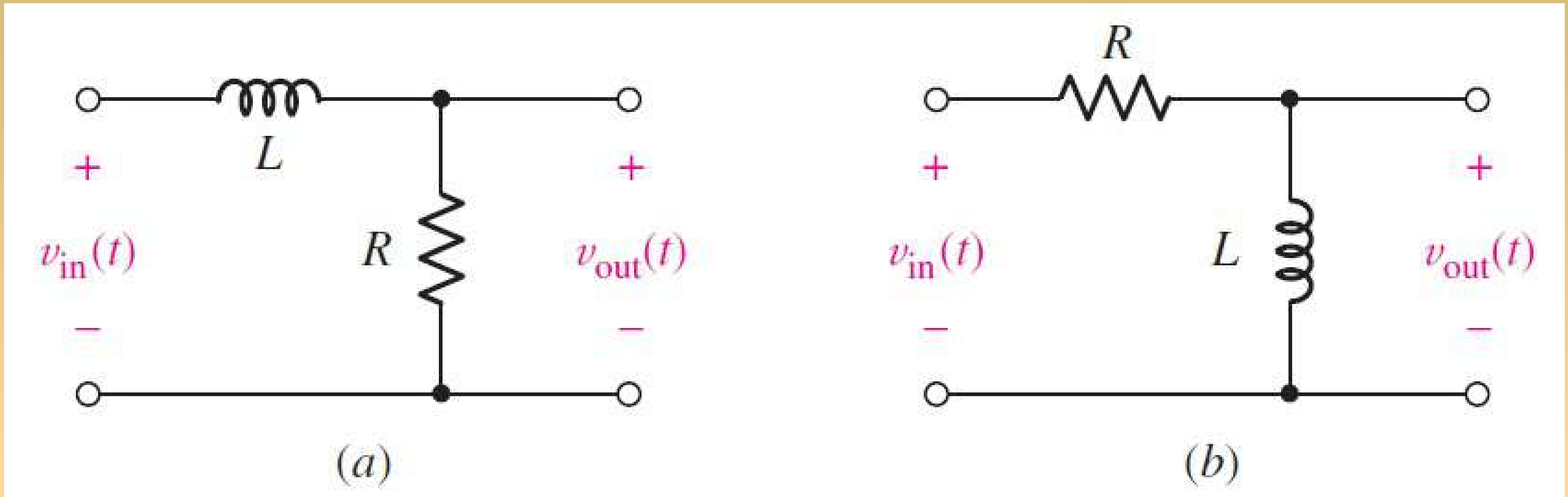
For the source-free circuit, determine expressions for i_1 and i_2 for $t > 0$, given the initial conditions $i_1(0) = i_2(0) = 11$ A.

Problem - 7



If a current source $i_1(t) = u(t)$ A is present at a-b with the arrow entering a, find **$H(s) = V_{cd}/I_1$**, and specify the natural frequencies present in $v_{cd}(t)$.

Problem - 8



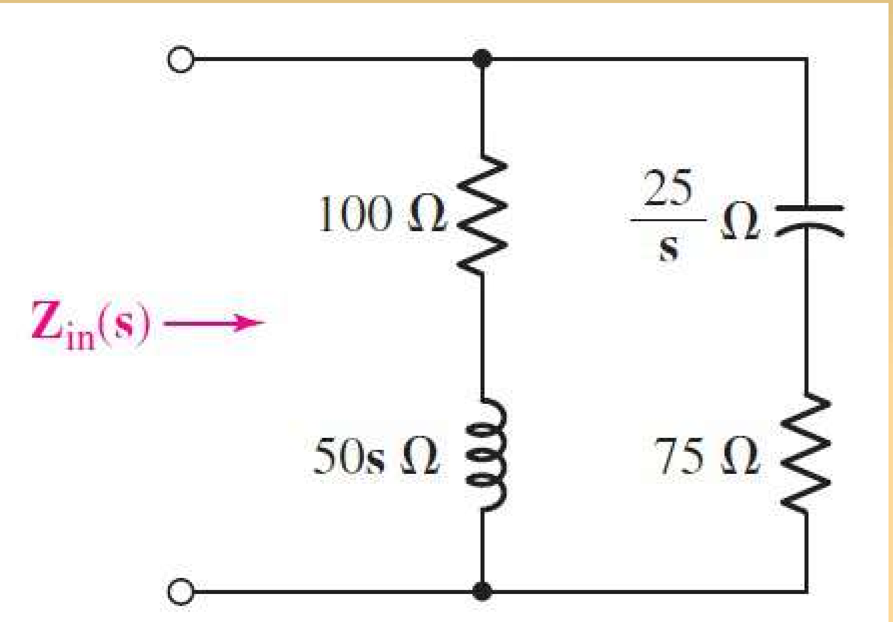
For each of the above two networks, (a) write the transfer function **H(s) ≡ $\mathbf{V_{out}(s)/V_{in}(s)}$**; (b) determine the poles and zeros of **H(s)**.

Problem - 9

A particular network is known to be characterized by the transfer function,

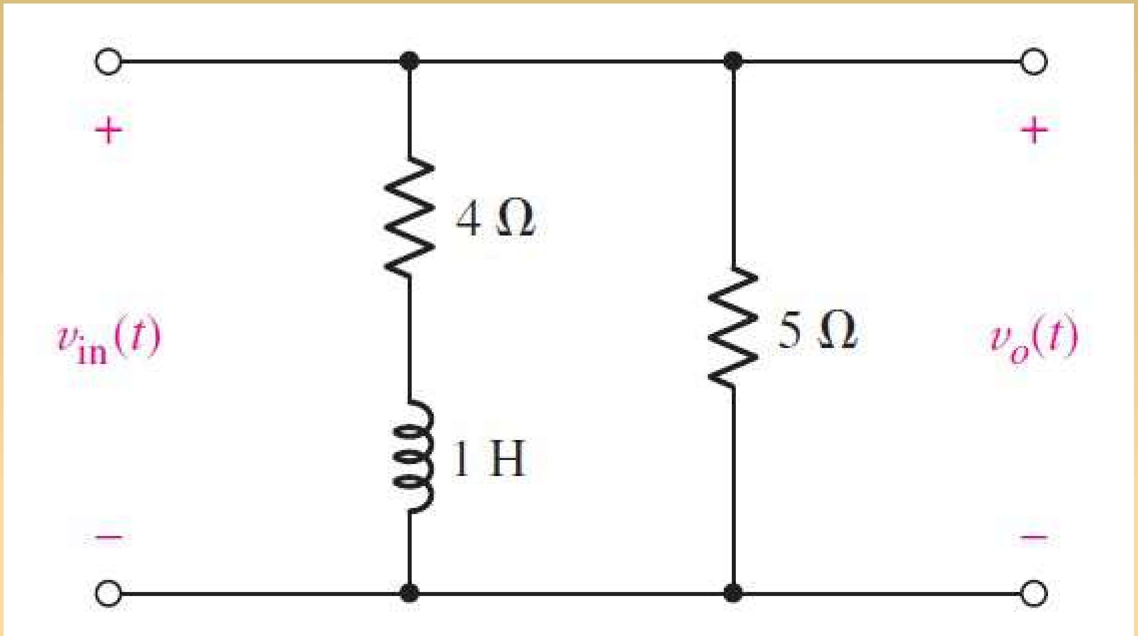
H(s) = s + 1**/(s^2 +** 23**s +** 60**)**. Determine the critical frequencies of the output if the input is (a) $2u(t) + 4\delta(t)$; (b) $-5e^{-t}u(t)$; (c) $4te^{-2t}u(t)$; (d) $5\sqrt{2}e^{-10t}\cos 5t\, u(t)$ V

Problem - 10



For the network, determine the critical frequencies of $\mathbf{Z_{in}(s)}$.

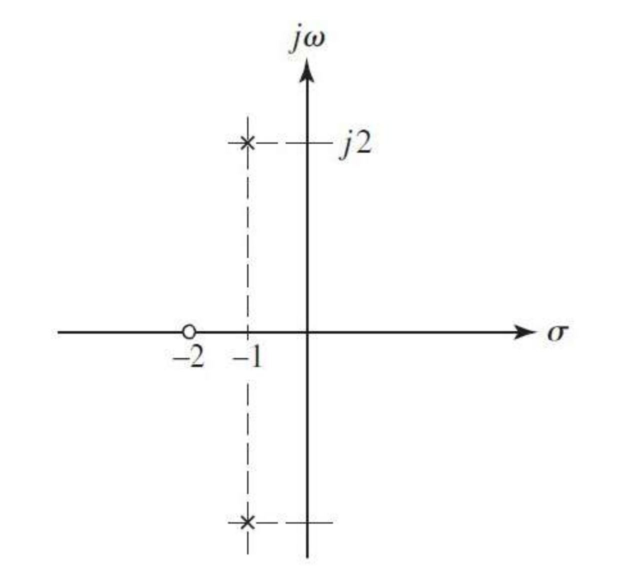
Problem - 11



(a) Determine the impulse response h(t) of the network.

(b) Use convolution to determine $v_o(t)$ if $v_{in}(t) = 8u(t)$ V.

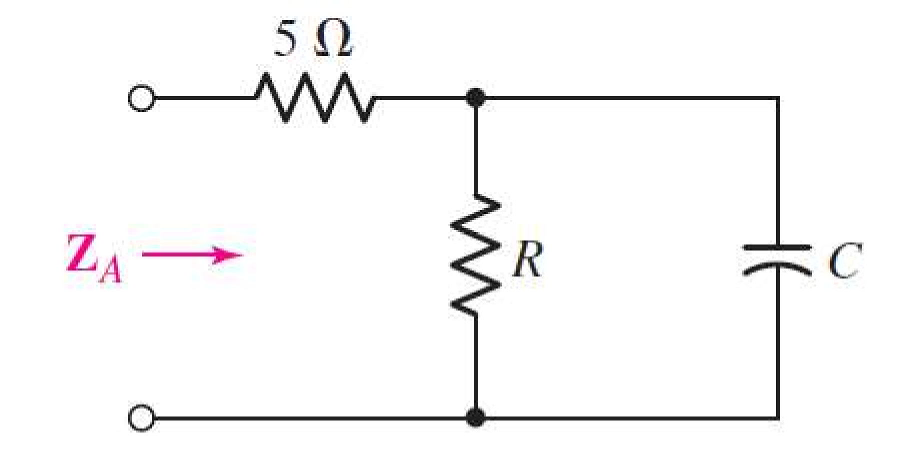
Problem - 12



The partially labeled pole-zero constellation of a particular transfer function **H(s)** is shown here. Obtain an expression for **H(s)** if **H**(0) is equal to

(a) 1; (b) −5. (c) Is the system represented by **H(s)** expected to be stable or unstable? Explain.

Problem - 13



The three-element network has an input impedance $\mathbf{Z}_A(\mathbf{s})$ that has a zero at $\mathbf{s} = -10 + j0$. If a 20 Ohm resistor is placed in series with the network, the zero of the new impedance shifts to $\mathbf{s} = -3.6 + j0$. Calculate R and C.

Problem - 14

Let $\mathbf{H}(\mathbf{s}) = 100(\mathbf{s} + 2)/(\mathbf{s}^2 + 2\mathbf{s} + 5)$.

(a) show the pole-zero plot for $\mathbf{H}(\mathbf{s})$;

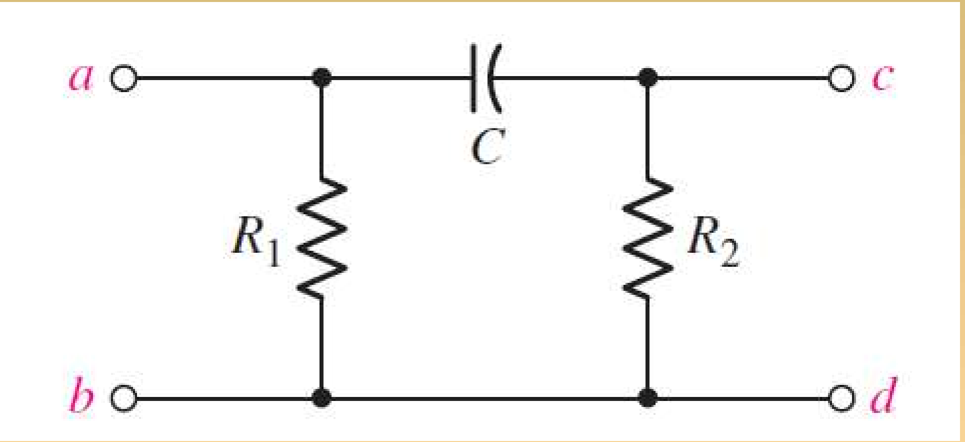
(b) find $\mathbf{H}(j\omega)$;

(c) find $|\mathbf{H}(j\omega)|$;

(d) sketch $|\mathbf{H}(j\omega)|$ versus ω;

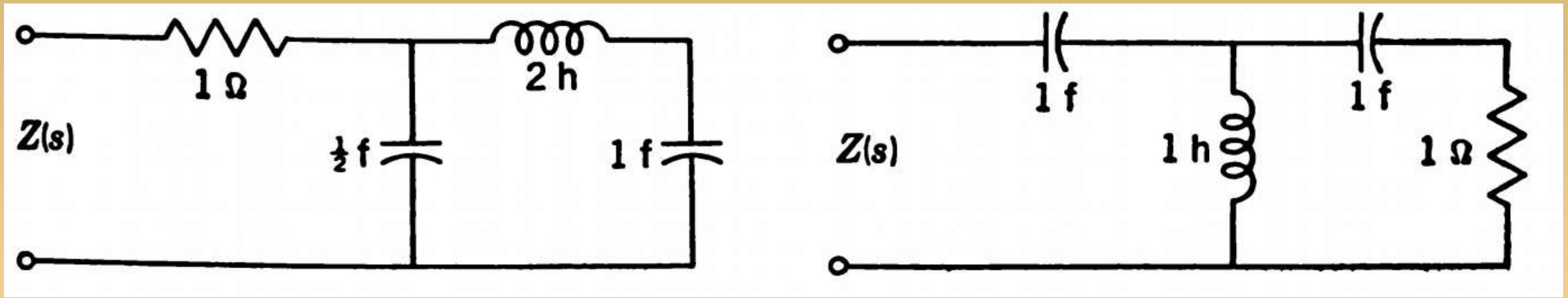
(e) find ω_{max}, the frequency at which $|\mathbf{H}(j\omega)|$ is a maximum.

Problem - 15



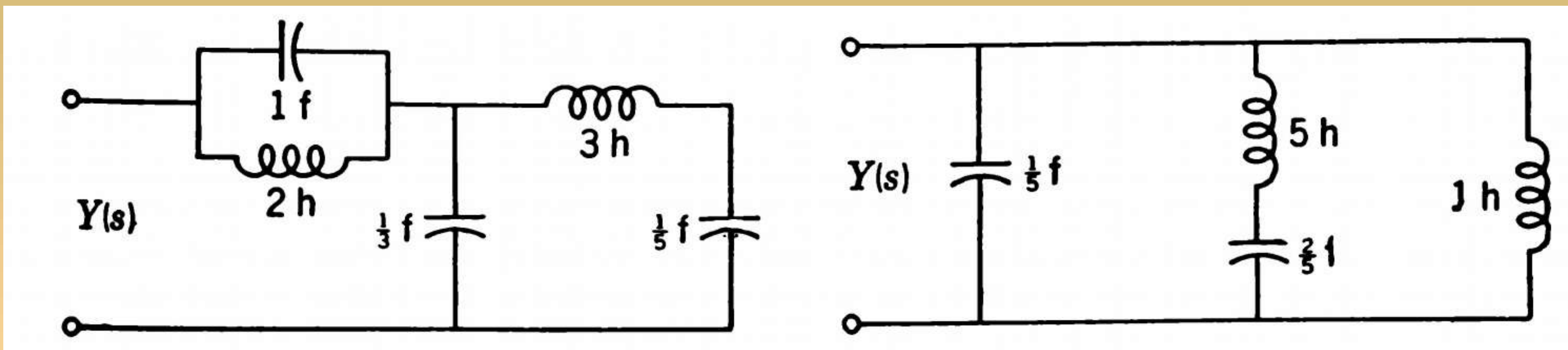
In the network, a current source $i_x(t) = 2u(t)$ A is connected between terminals c and d such that the arrow of the source points upward. Determine the resulting natural frequencies present in the voltage $v_{ab}(t)$.

Problem - 16



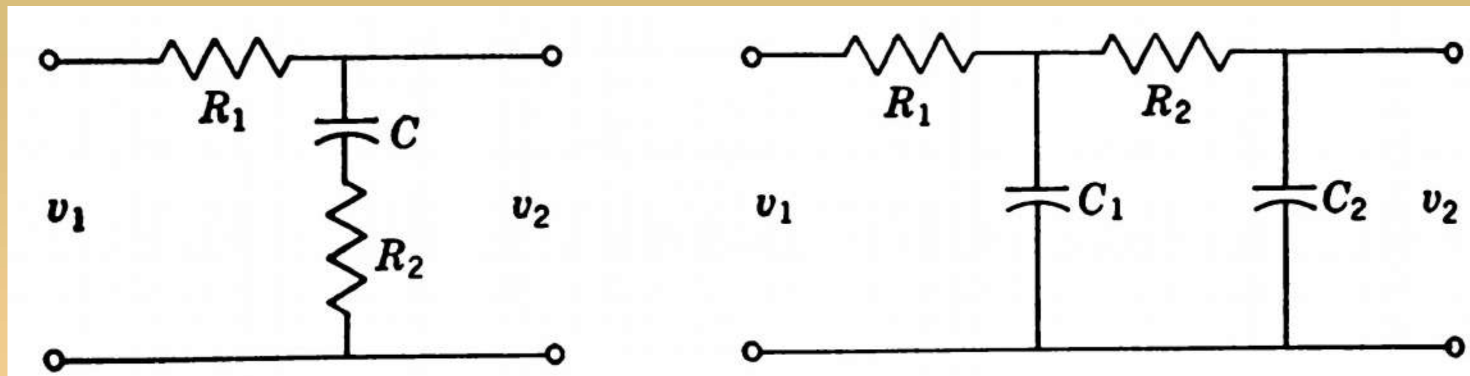
Find the driving point impedances for the given networks. Arrange the polynomials of these functions with the highest ordered terms normalized to unity coefficient.

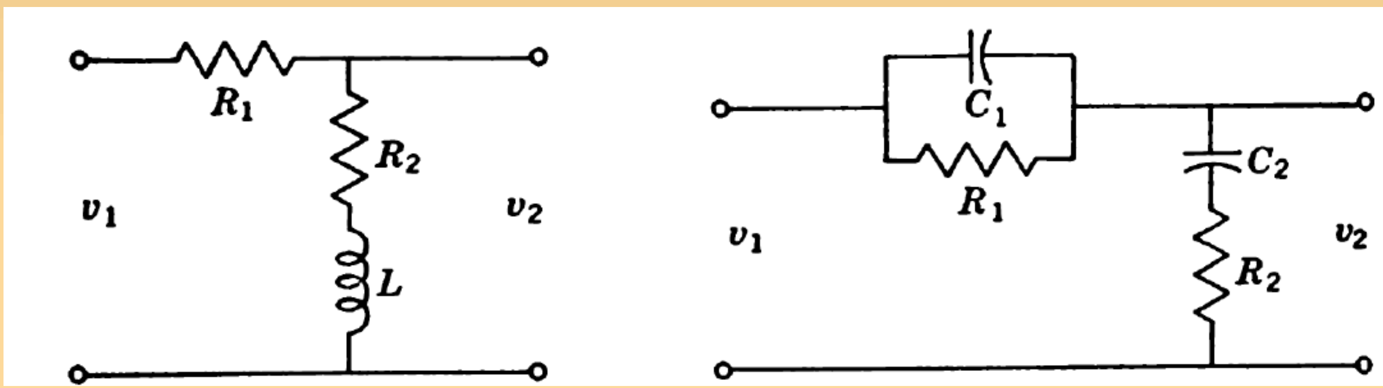
Problem - 17



Find the driving point admittance for the networks. Arrange the polynomials with the highest ordered terms normalized to unity coefficient.

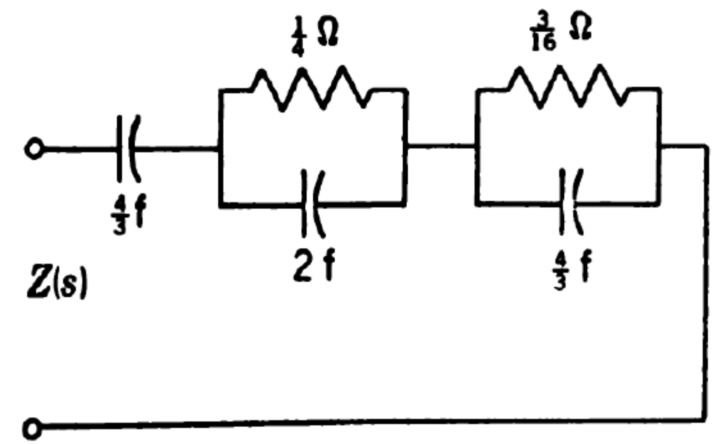
Problem - 18

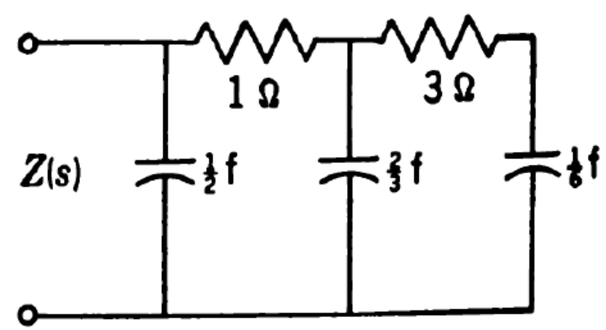


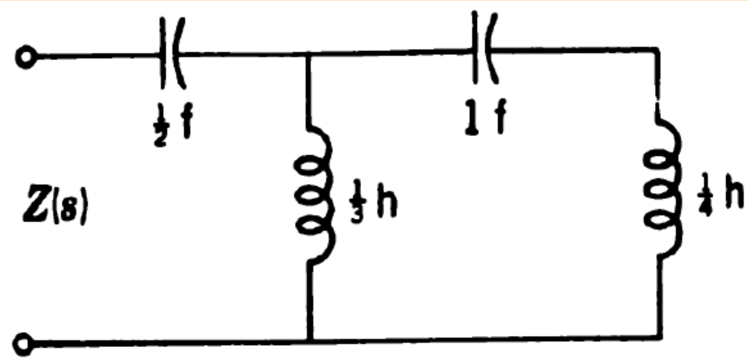


For the given networks, find the transfer function, the ratio of output voltage to the input voltage. Arrange the polynomials with the highest ordered terms normalized to unity coefficient.

Problem - 19







Find the driving point impedances of the given networks.

Problem - 20

For each case, find the pole zero configuration for I(s) that gives the time domain response as

(a) $i(t) = 2e^{-t} - 1e^{-5t}$

(b) $i(t) = (7/4)e^{-t} - 2e^{-3t} + (1/4)e^{-5t}$

Problem - 21

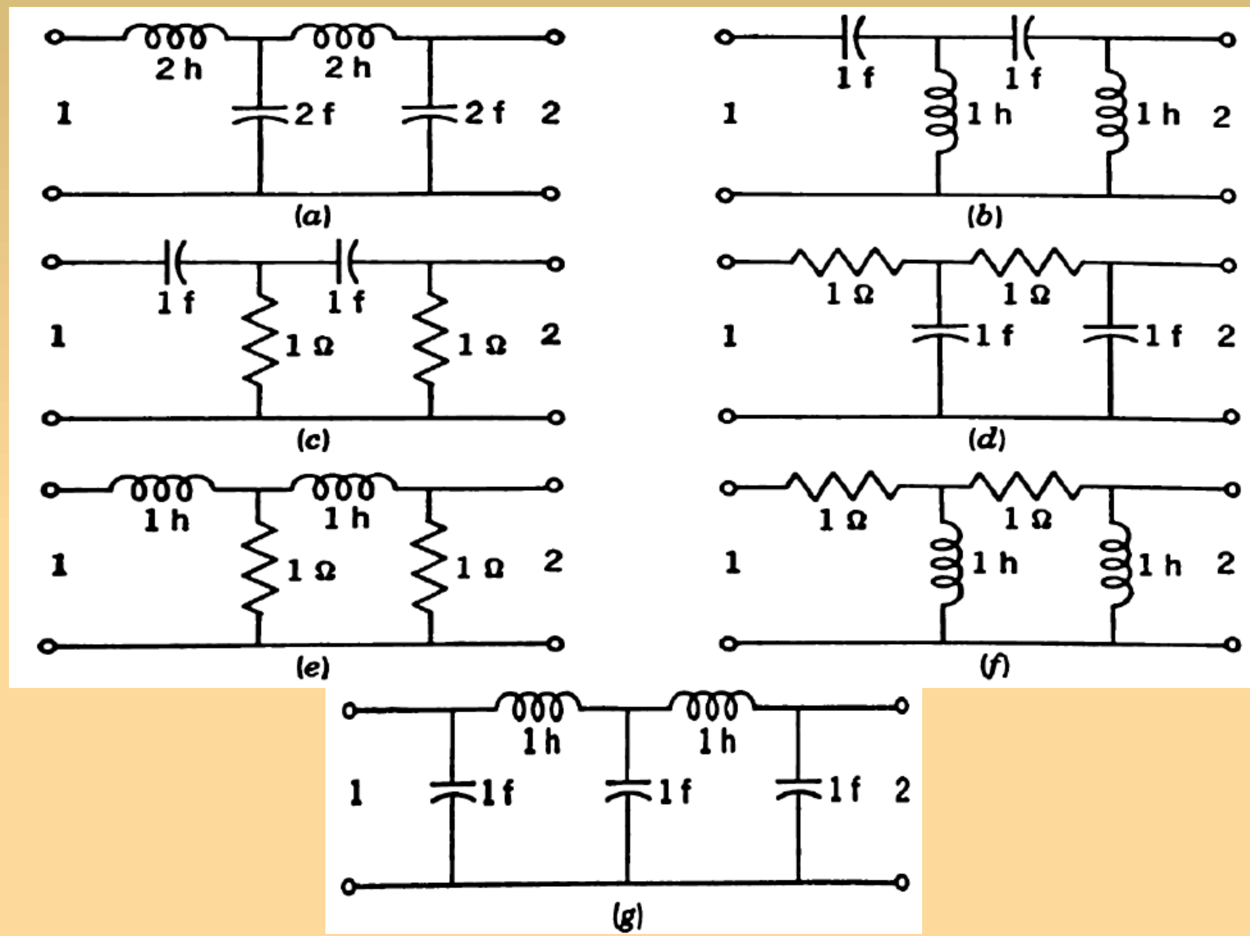
Poles	Zeros
$-2 \pm j1$	none
-5	

Poles	Zeros
$-1 \pm j2$	-6
-3	

(a) Given that the scale factor for a current transform I(s) has the 10 and the finite poles and zeros given in the left describe the system. Find the time domain response i(t) corresponding to this I(s).

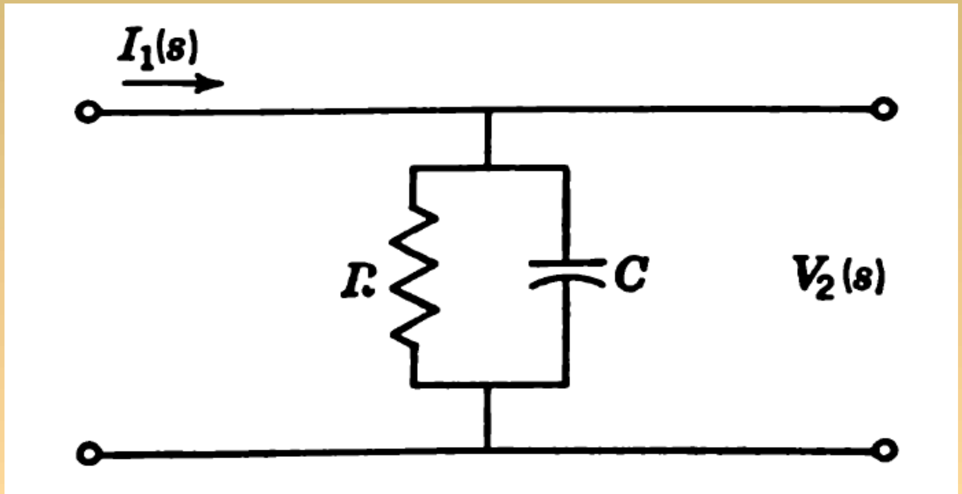
(b) Given that the scale factor for a current transform I(s) has the 10 and the finite poles and zeros given in the right describe the system. Find the time domain response i(t) corresponding to this I(s).

Problem - 22



For each of the network, find the transfer impedance $Z_{tr}(s)=V_{out}(s)/I_{in}(s)$ and the voltage ratio transfer function $G(s)=V_{out}(s)/V_{in}(s)$.

Problem - 23



The given network is driven by a current source I_1. The output voltage is V_2.

(a) Find the transfer impedance $Z_{21}(s)=V_2(s)/I_1(s)$.

(b) Show the pole-zero configuration for $Z_{21}(s)$.

Problem - 24

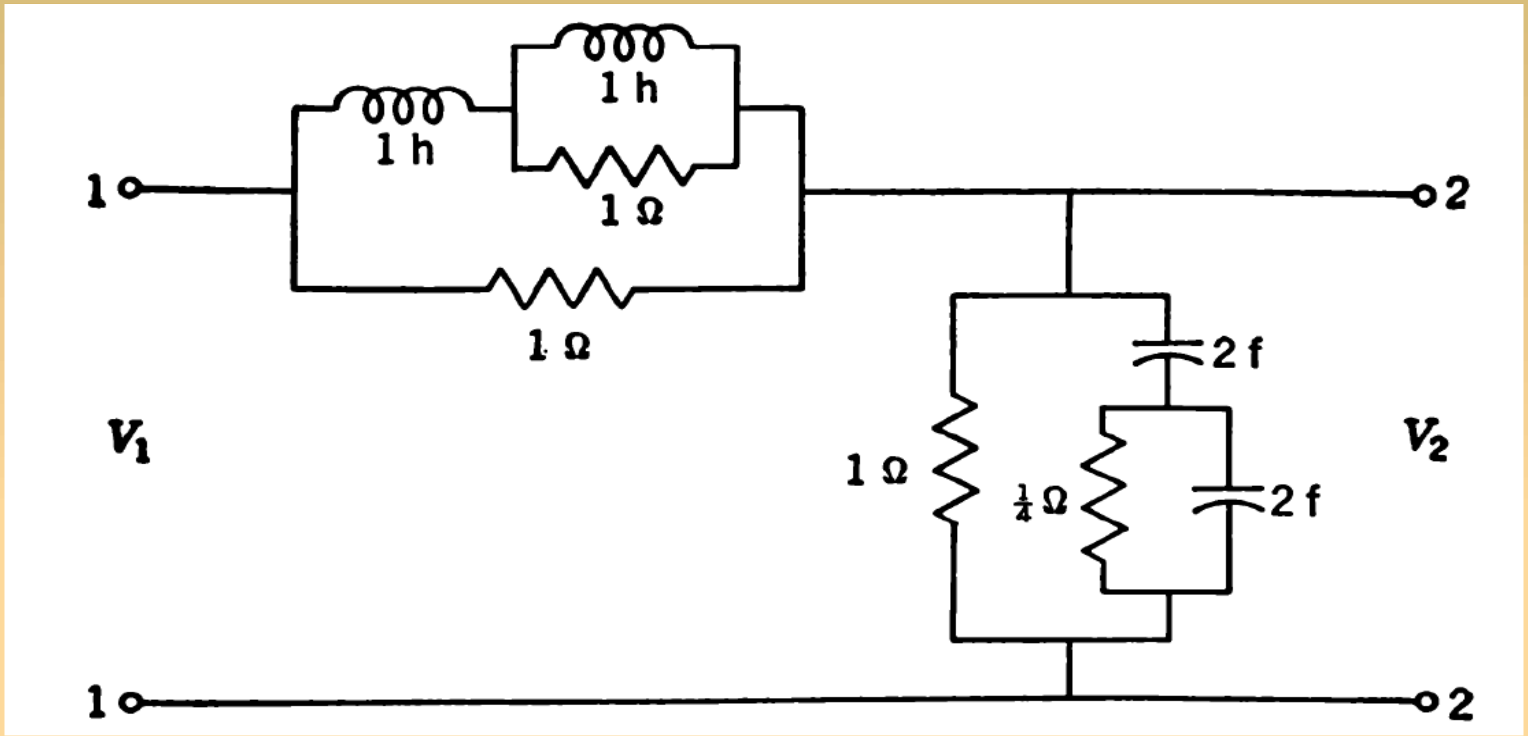
For a given network it is known that

$Z_{21}(s) = V_2(s)/I_1(s) = (s-s_1)(s-s_2)/s$

where $s_1=-1+j10$ and $s_2=-1-j10$.

If $i_1(t)=e^{-0.5t}$, find $v_2(t)$.

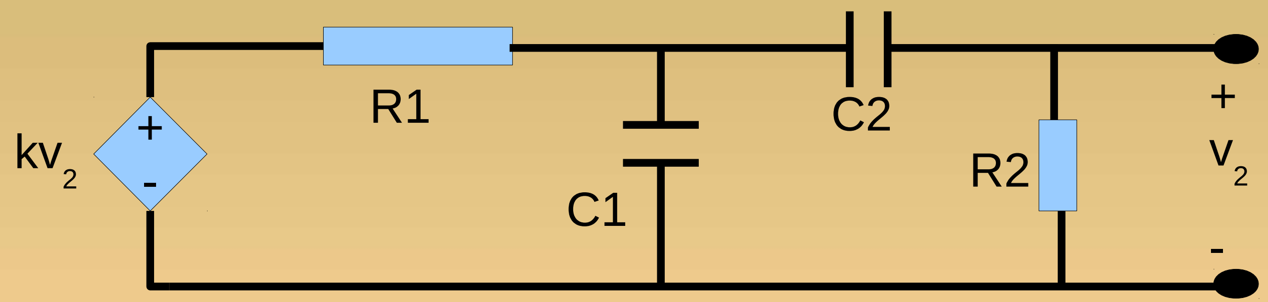
Problem - 25



(a) For the network, find out the input impedance, $Z_{11}(s)$ of the terminal-pair 1.

(b) Find the transfer function $G(s) = V_2(s)/V_1(s)$.

Problem - 26



(a) For the network, let R1=R2=1 Ohm, C1=1 F and C2=2 F. For what values of k will the network be stable?

(b) If k=2, C1=1 F and R2=1 Ohm, determine the relationship that must exist between R1 and C2 for the system to oscillate.

R-L-C Circuits and Their Frequency Response

Problem - 1

(a) A parallel resonant circuit is composed of the elements R = 8 kΩ, L = 50 mH, and C = 80 nF. Compute (a) ω_0; (b) Q_0; (c) ω_d ; (d) α; (e) ζ.

(b) Determine the values of R, L, and C in a parallel resonant circuit for which ω_0 = 1000 rad/s, ω_d = 998 rad/s, and $\mathbf{Y}_{in}$ = 1 mS at resonance.

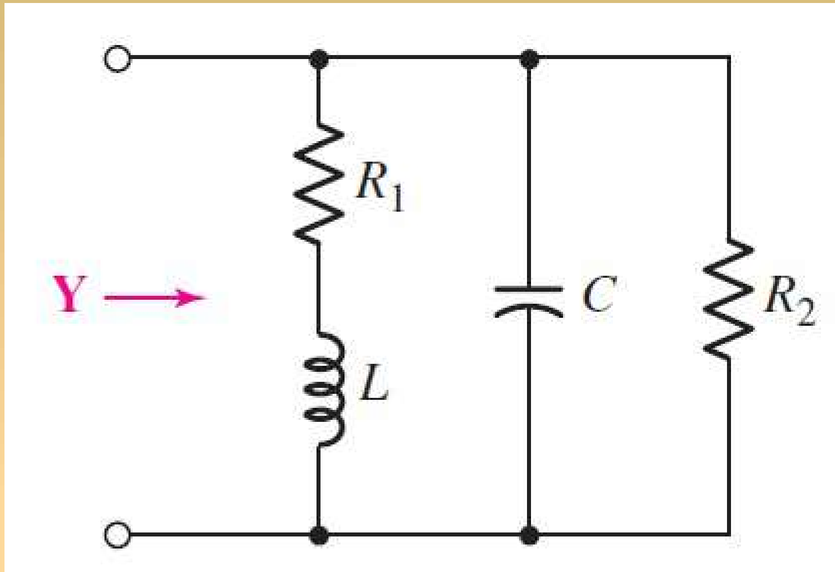
Problem - 2

Estimate the location of the two half-power frequencies of the voltage response of a parallel RLC network for which R =40kΩ, L=1 H, and C=1/64 μF, determine the approximate value of the admittance for an operating frequency of 8200 rad/s.

Problem - 3

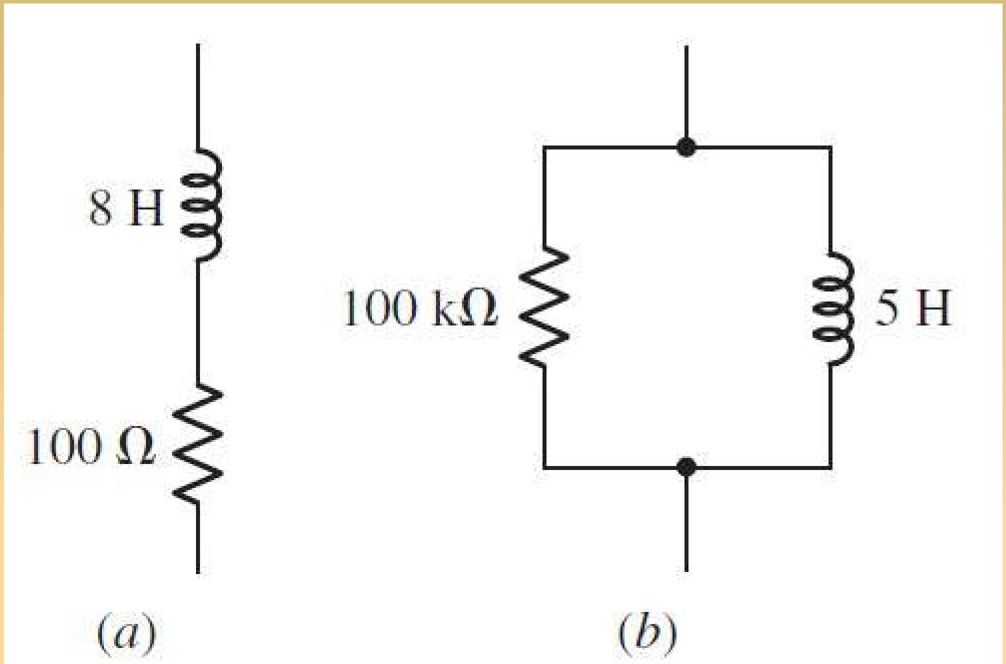
A series resonant circuit has a bandwidth of 100 Hz and contains a 20 mH inductance and a 2 μF capacitance. Determine (a) f_0; (b) Q_0; (c) Z_{in} at resonance; (d) f_2.

Problem - 4



Referring to the circuit of Fig. 16.9a, let R1 = 1 kΩ and C = 2.533 pF. Determine the inductance necessary to select a resonant frequency of 1 MHz.

Problem - 5



(a) At ω = 1000 rad/s, find a parallel network that is equivalent to the series combination in Fig. (a).

(b) Find a series equivalent for the parallel network shown in Fig. (b), assuming ω = 1000 rad/s.

Problem - 6

The series combination of 10 Ω and 10 nF is in parallel with the series combination of 20 Ω and 10 mH.

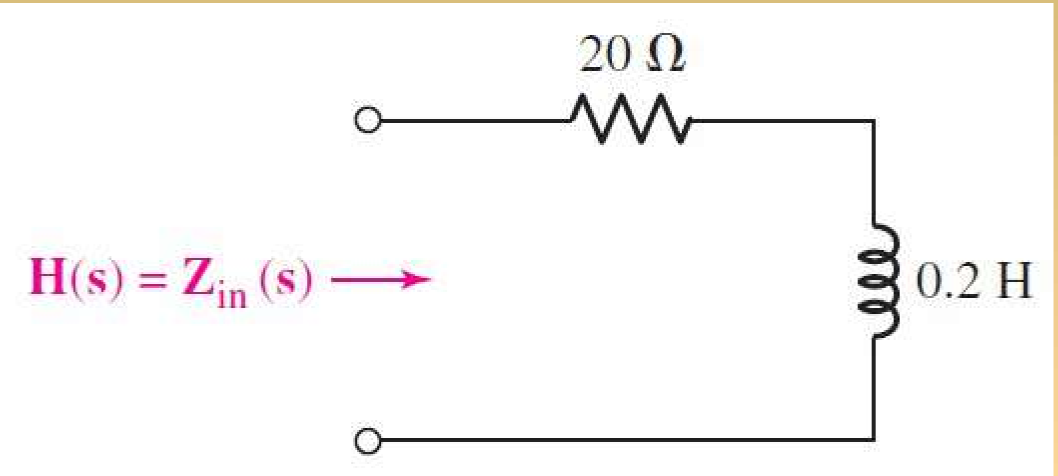
(a) Find the approximate resonant frequency of the parallel network.

(b) Find the Q of the RC branch.

(c) Find the Q of the RL branch.

(d) Find the three-element equivalent of the original network.

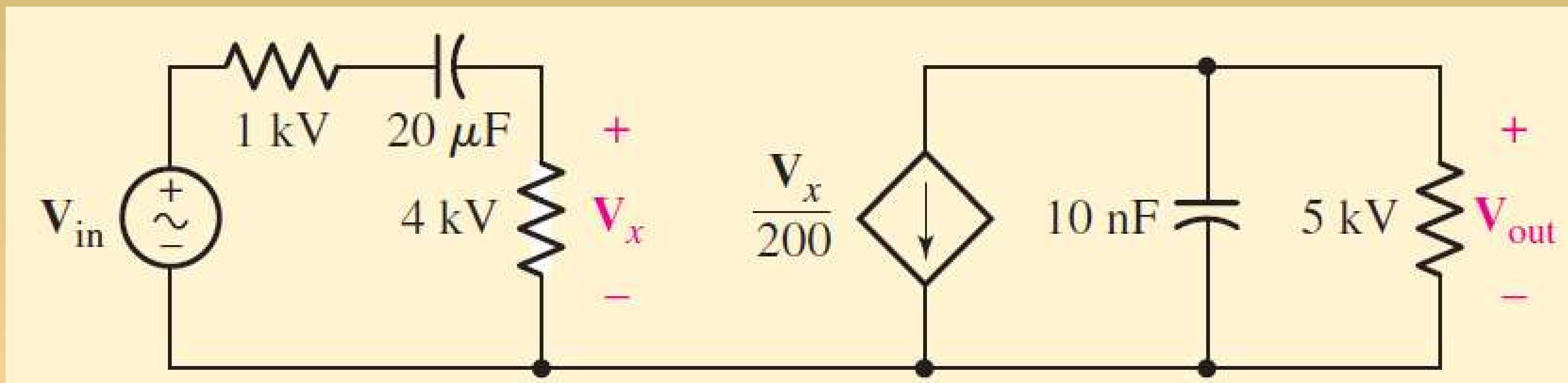
Problem - 7



(a) Obtain the Bode plot of the input impedance of the network.

(b) Also draw the Bode phase plot for the same network function.

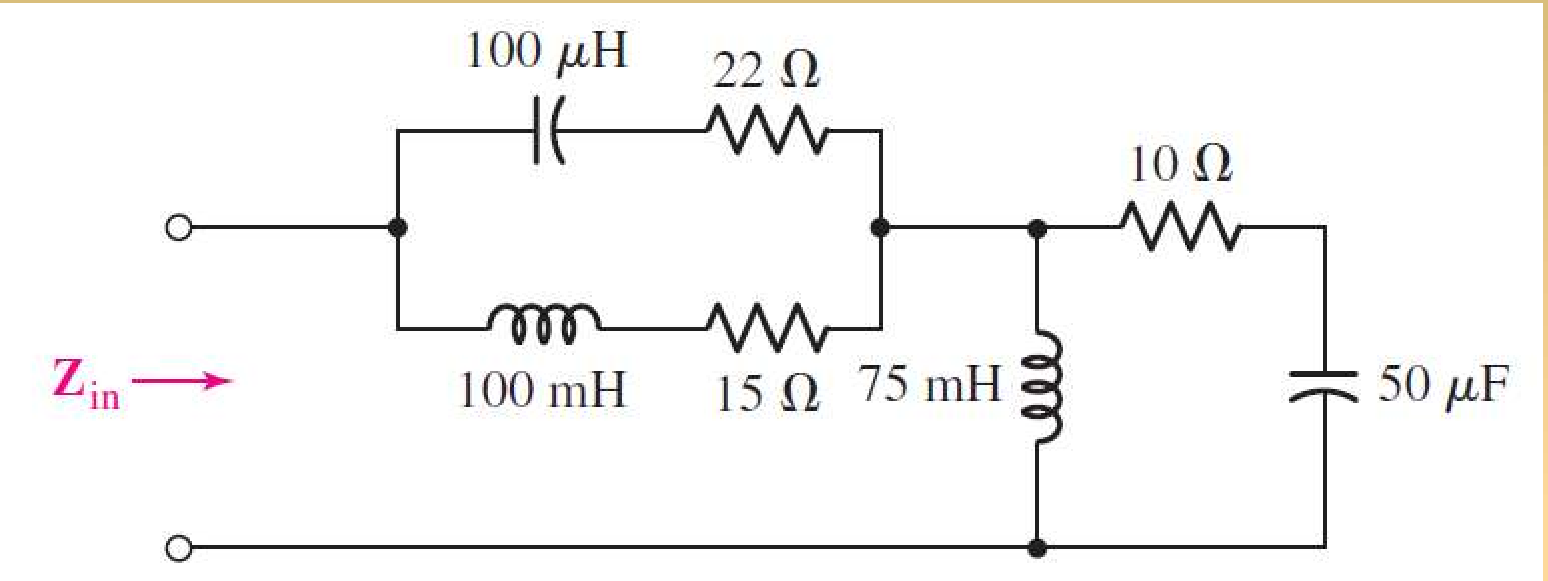
Problem - 8



(a) Obtain the Bode plot for the gain of the circuit.

(b) Draw the phase plot for the same transfer function.

Problem - 9



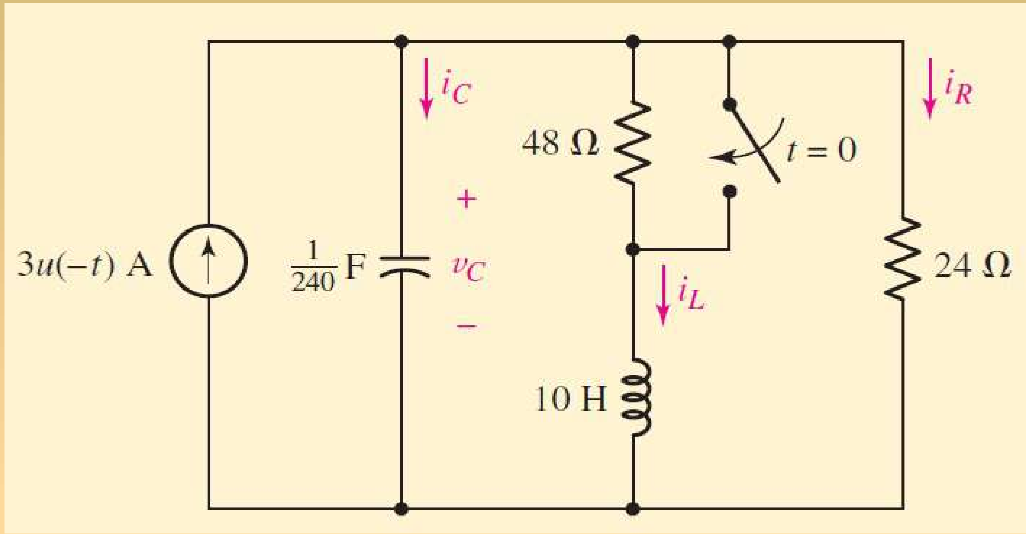
For the network, determine the resonant frequency and the corresponding value of $|Z_{in}|$.

Problem - 10

(a) Consider a parallel RLC circuit having an inductance of 10 mH and a capacitance of 100 μF. Determine the resistor values that would lead to overdamped and underdamped responses.

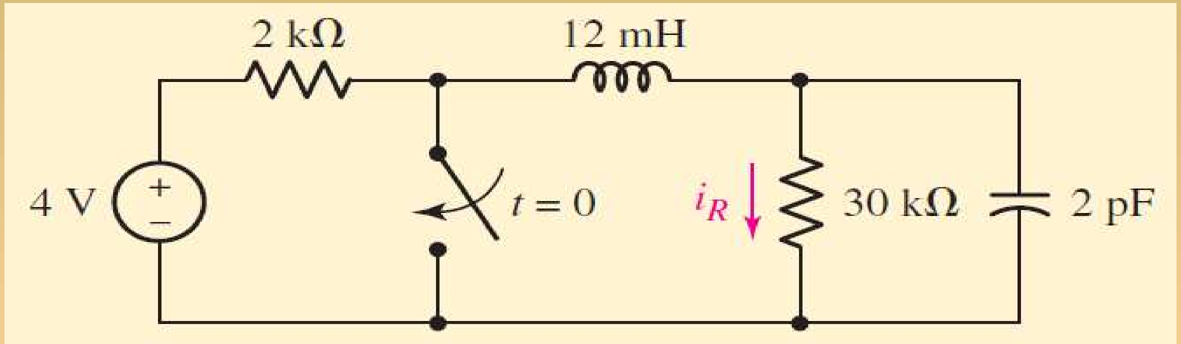
(b) A parallel RLC circuit contains a 100 Ω resistor and has the parameter values $\alpha = 1000\ s^{-1}$ and $\omega_0 = 800$ rad/s. Find (i) C; (ii) L; (iii) s_1; (iv) s_2.

Problem - 11



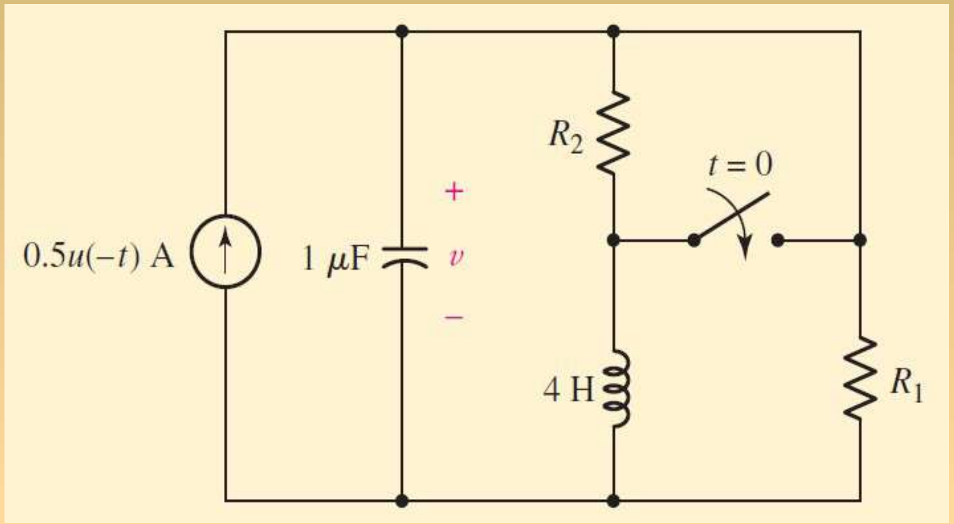
After being open for a long time, the switch in the network closes at t = 0. Find (a) $i_L(0^-)$; (b) $v_C(0^-)$; (c) $i_R(0^+)$; (d) $i_C(0^+)$; (e) $v_C(0.2)$.

Problem - 12



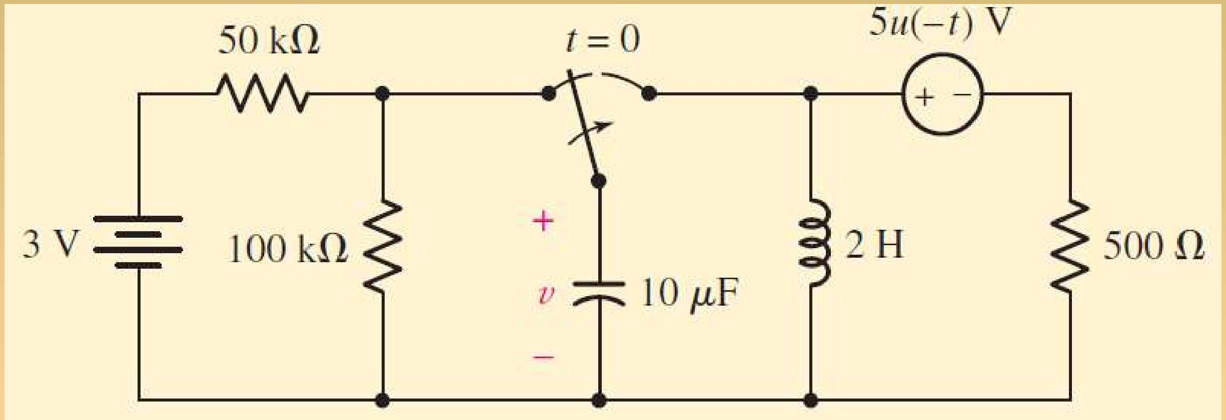
The circuit reduces to a simple parallel RLC circuit after t = 0. Determine an expression for the resistor current i_R valid for all time.

Problem - 13



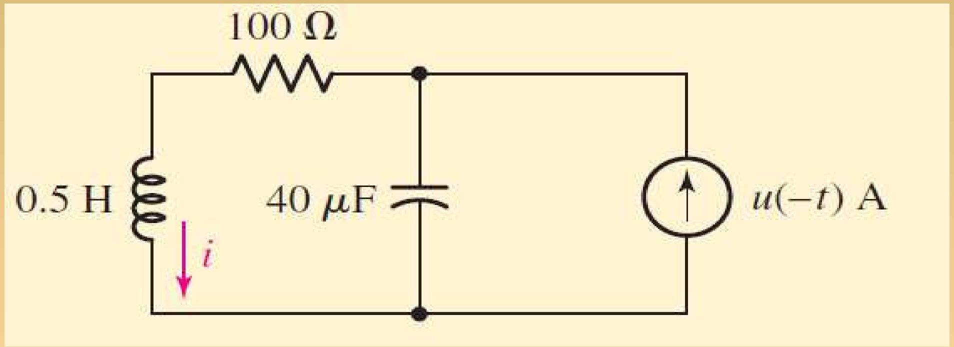
(a) Choose R_1 in the circuit so that the response after t = 0 will be critically damped. (b) Now select R_2 to obtain v(0) = 100 V. (c) Find v(t) at t = 1 ms.

Problem - 14



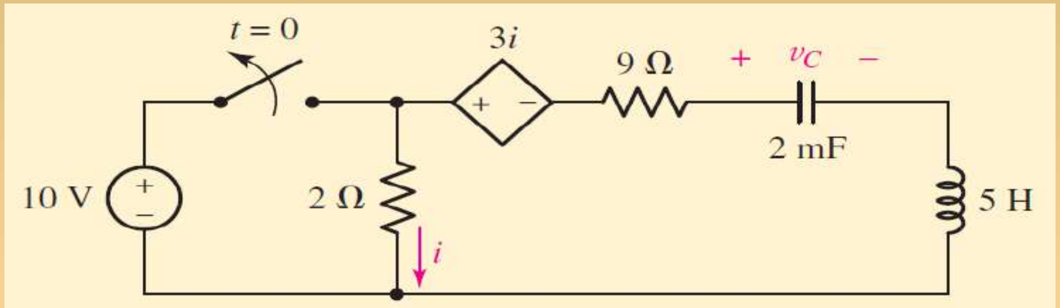
The switch in the circuit has been in the left position for a long time; it is moved to the right at t = 0. Find (a) dv/dt at $t = 0^+$; (b) v at t = 1 ms; (c) t_0, the first value of t greater than zero at which v = 0.

Problem - 15



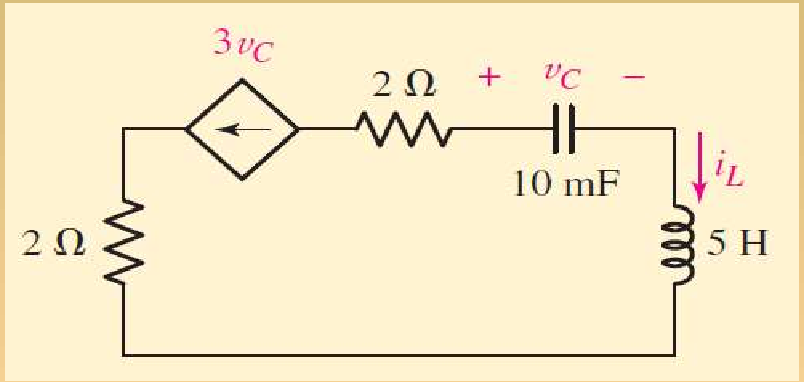
With reference to the circuit, find (a) α; (b) ω_0; (c) $i\ (0^+)$; (d) di/dt at $t=0^+$; (e) i (12 ms).

Problem - 16



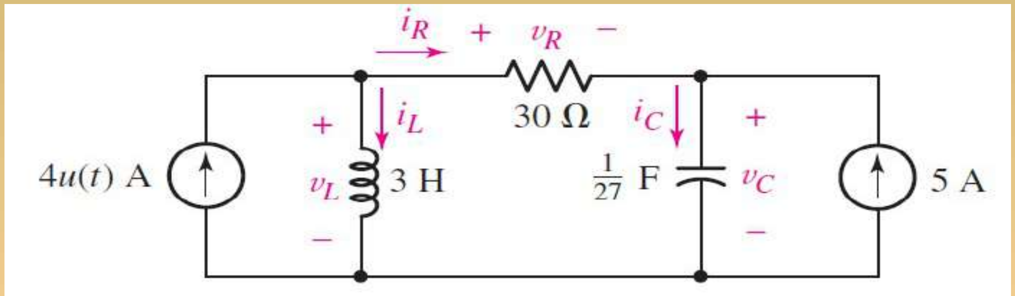
Find an expression for $v_C(t)$ in the circuit, valid for $t > 0$.

Problem - 17



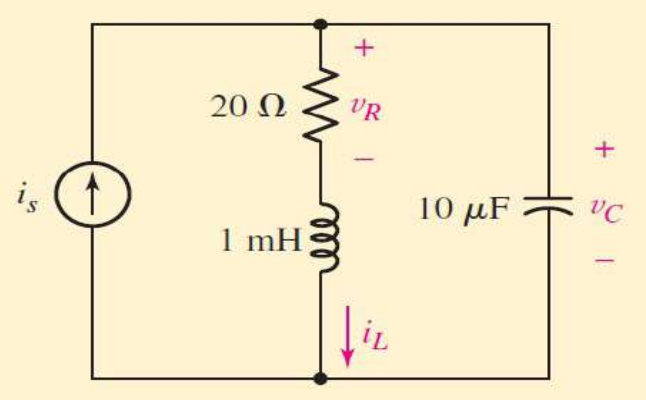
Find an expression for $i_L(t)$ in the circuit, valid for $t > 0$, if $v_C(0^-) = 10$ V and $i_L(0^-) = 0$.

Problem - 18



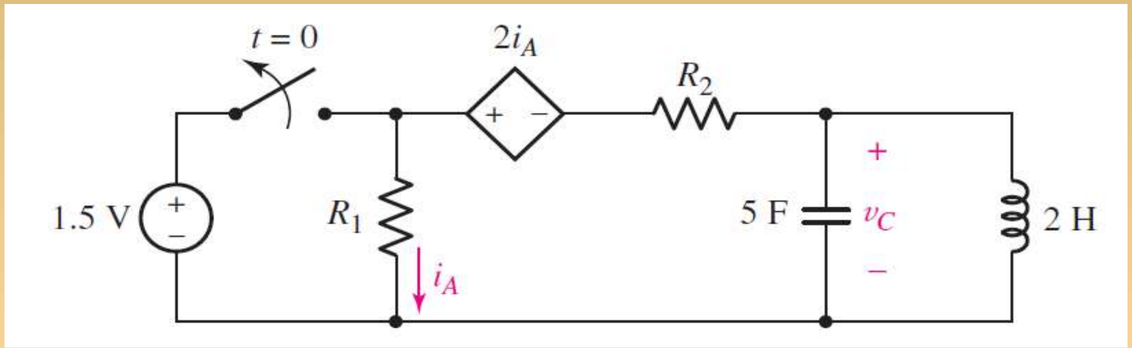
There are three passive elements in the circuit, and a voltage and a current are defined for each. Find the values of these six quantities at both $t = 0^-$ and $t = 0^+$.

Problem - 19



Let $i_s = 10u(-t) - 20u(t)$ A. Find (a) $i_L(0^-)$; (b) $v_C(0^+)$; (c) $v_R(0^+)$; (d) $i_L(\infty)$; (e) $i_L(0.1\text{ ms})$.

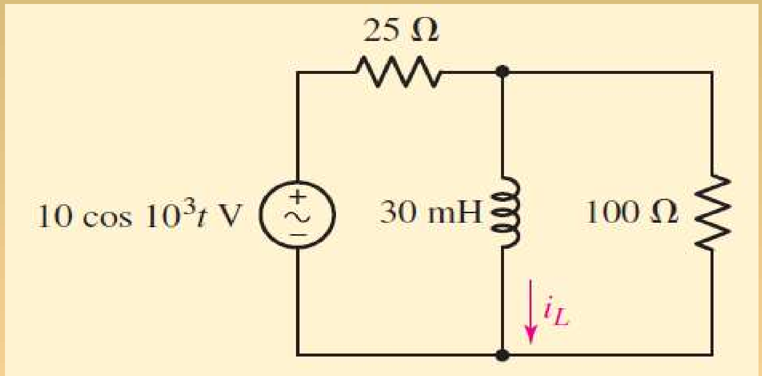
Problem - 20

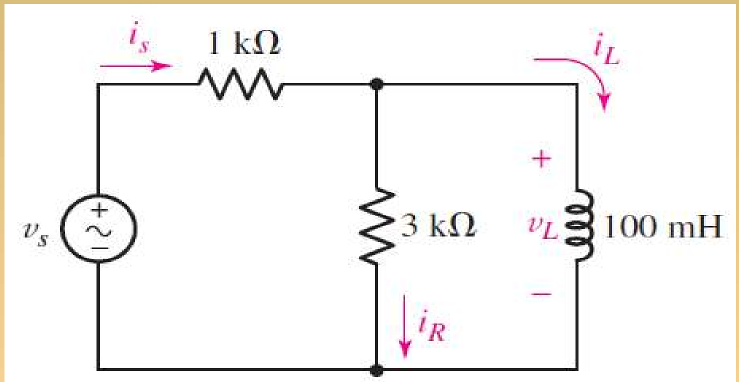


For the circuit, the two resistor values are R_1 = 0.752 Ω and R_2 = 1.268 Ω, respectively. (a) Obtain an expression for the energy stored in the capacitor, valid for all t > 0; (b) determine the settling time of the current labeled i_A.

Sinusoidal Steady State Analysis

Problem - 1

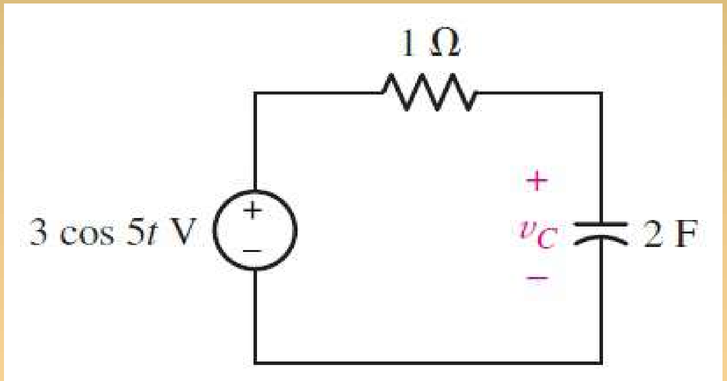




(i) Find the current i_L in the left-sided circuit, if the transients have already died out.

(ii) For the right-sided circuit, assume v_s = 40 cos 8000t V. Find the value at t = 0 for (a) i_L; (b) v_L ; (c) i_R; (d) i_s.

Problem - 2



For the simple RC circuit, substitute an appropriate complex source and use it to solve for the steady-state capacitor voltage.

Problem - 3

(i) Evaluate and express the result in rectangular form:

(a) [(2Ang(30°))(5Ang(−110°))](1 + j2); (b) (5Ang(−200°)) + 4Ang(20°).

Evaluate and express the result in polar form:

(c) (2 − j7)/(3 − j); (d) 8 − j4 +[(5Ang(80°))/(2Ang(20°))].

(ii) If the use of the passive sign convention is specified, find the (a) complex voltage that results when the complex current $4e^{j800t}$ A is applied to the series combination of a 1 mF capacitor and a 2 Ohm resistor; (b) complex current that results when the complex voltage $100e^{j2000t}$ V is applied to the parallel combination of a 10 mH inductor and a 50 Ohm resistor.

Problem - 4

(i) Let $\omega = 2000$ rad/s and $t = 1$ ms. Find the instantaneous value of each of the currents given here in phasor form:

(a) $j10$ A; (b) $20 + j10$ A; (c) $20 + j\,(10\text{Ang}(20^\circ))$ A.

(ii) Transform each of the following functions of time into phasor form:

(a) $-5 \sin(580t - 110^\circ)$; (b) $3 \cos 600t - 5 \sin(600t + 110^\circ)$;

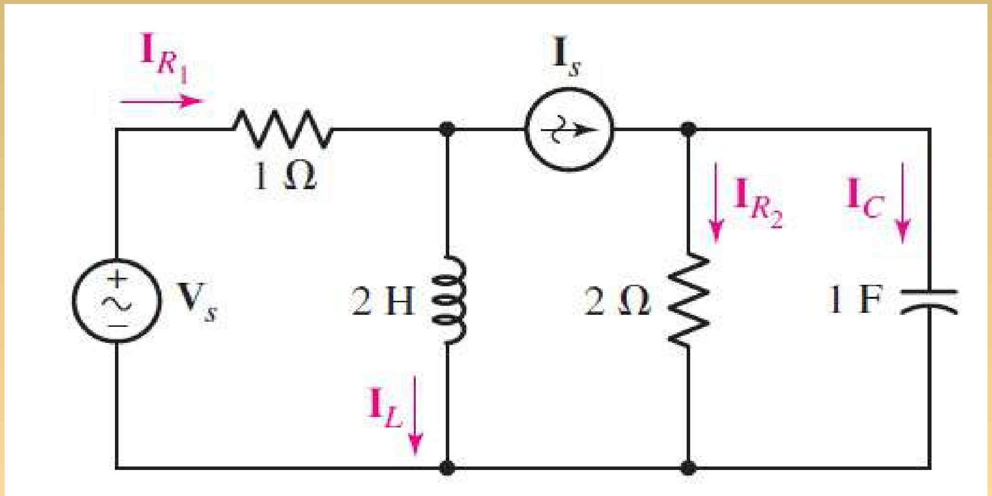
(c) $8 \cos(4t - 30^\circ) + 4 \sin(4t - 100^\circ)$.

Hint: First convert each into a single cosine function with a positive magnitude.

Problem - 5

Apply the voltage 8Ang(−50°) V at a frequency ω=100rad/s to a 4 H inductor, and determine the phasor current and the time-domain current.

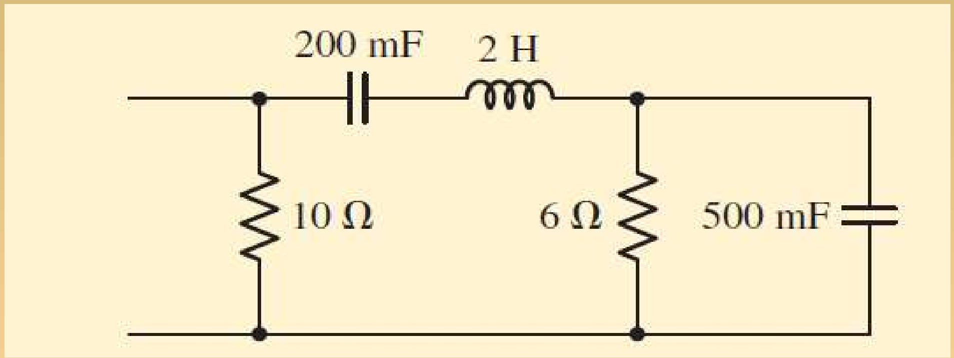
Problem - 6



(i) For the RLC circuit, determine I_s and $i_s(t)$ if both sources operate at $\omega = 2$ rad/s, and $I_C = 2\ \text{Ang}(28^\circ)$ A.

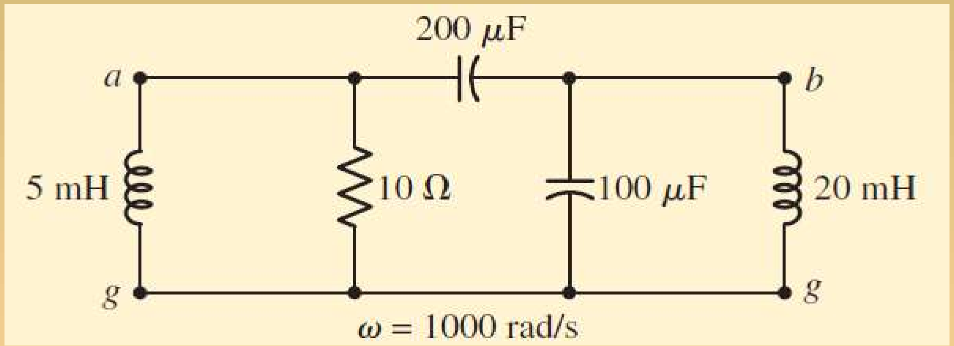
(ii) Assume that both sources operate at $\omega = 1$ rad/s. If $I_C = 2\text{Ang}(28^\circ)$ A and $I_L = 3\text{Ang}(53^\circ)$ A, calculate (a) I_s ; (b) V_s ; (c) i_{R1} (t).

Problem - 7



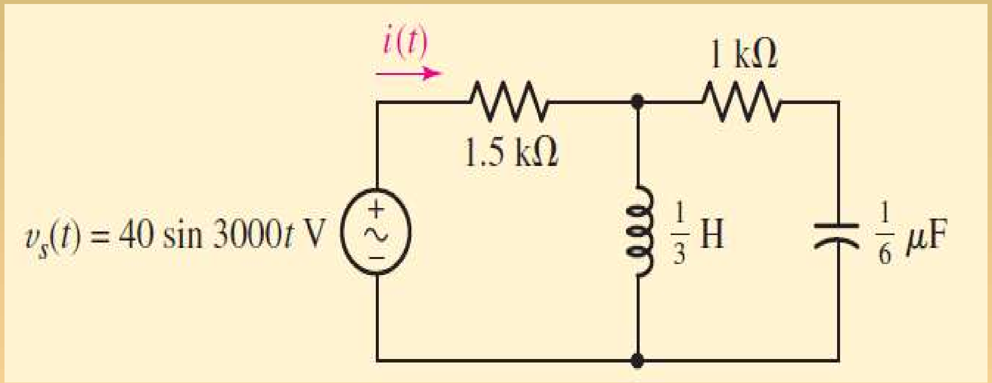
Determine the equivalent impedance of the network given an operating frequency of 5 rad/s.

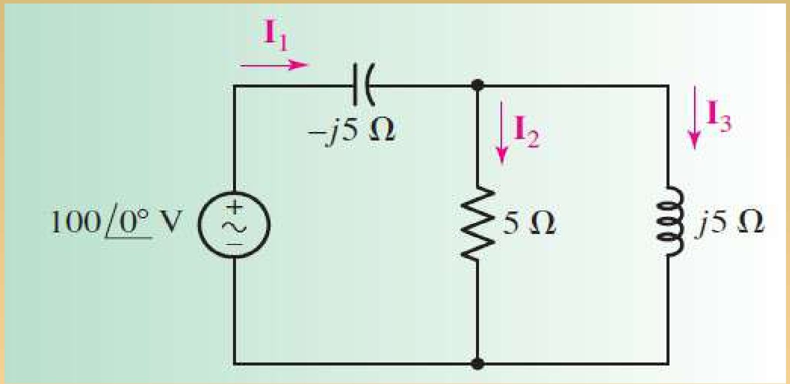
Problem - 8



With reference to the given network, find the input impedance Z_{in} that would be measured between terminals: (a) a and g; (b) b and g; (c) a and b.

Problem - 9





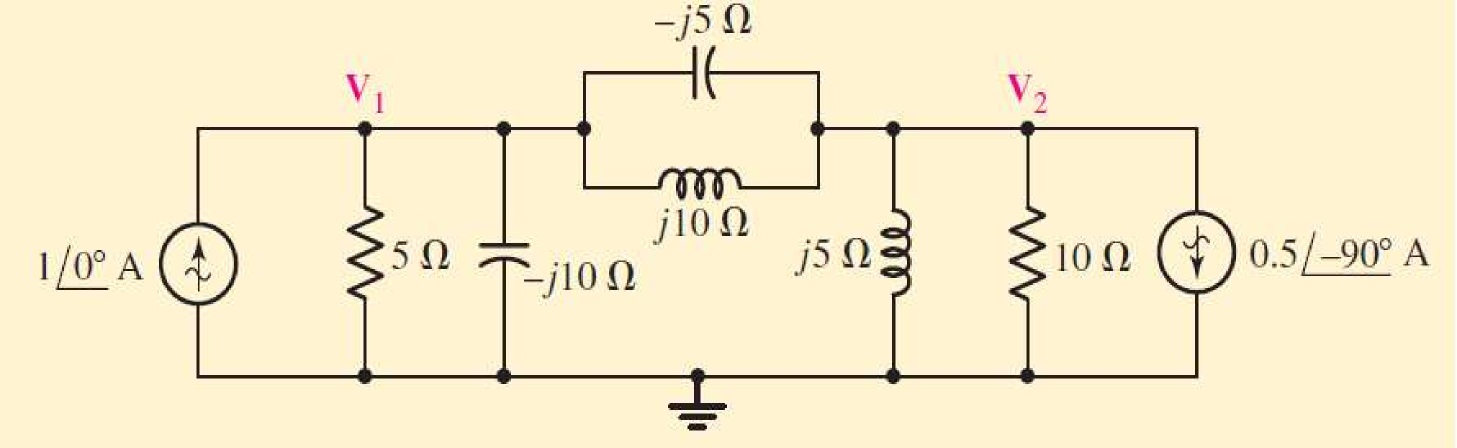
(i) Find the current i(t) in the left-sided circuit.

(ii) In the right-sided frequency-domain circuit, find (a) I_1; (b) I_2; (c) I_3.

Problem - 10

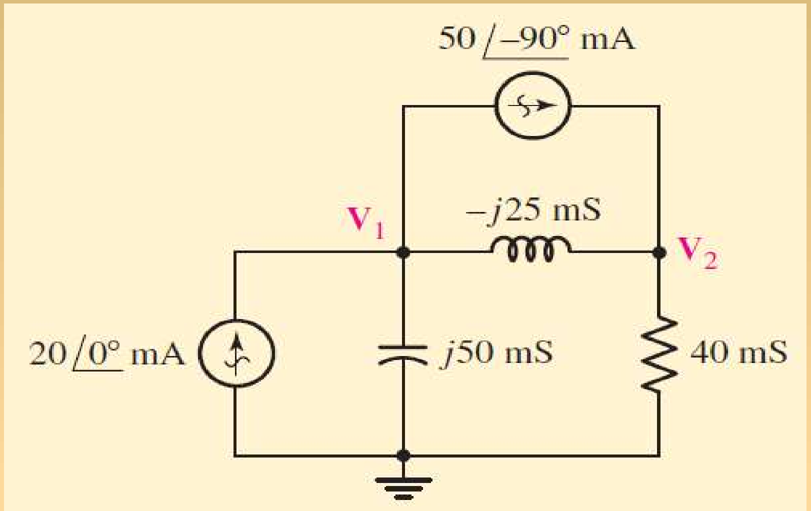
Determine the admittance (in rectangular form) of (a) an impedance $Z = 1000 + j400$; (b) a network consisting of the parallel combination of an 800 Ohm resistor, a 1 mH inductor, and a 2 nF capacitor, if $\omega = 1$ Mrad/s; (c) a network consisting of the series combination of an 800 Ohm resistor, a 1 mH inductor, and a 2 nF capacitor, if $\omega=1$ Mrad/s.

Problem - 11



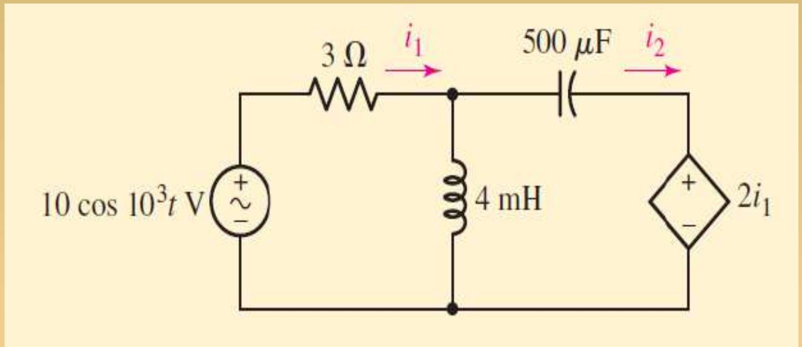
Find the time-domain node voltages $v_1(t)$ and $v_2(t)$ in the circuit.

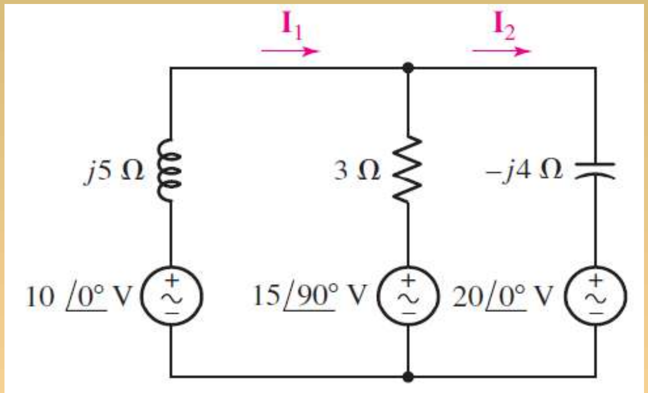
Problem - 12



Use nodal analysis on the circuit to find V_1 and V_2.

Problem - 13

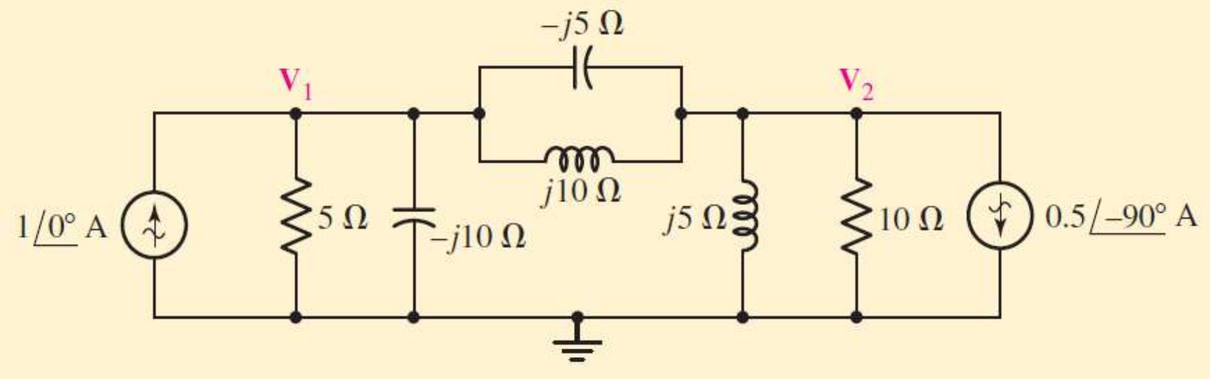




(i) Obtain expressions for the time-domain currents i_1 and i_2 in the left-sided circuit.

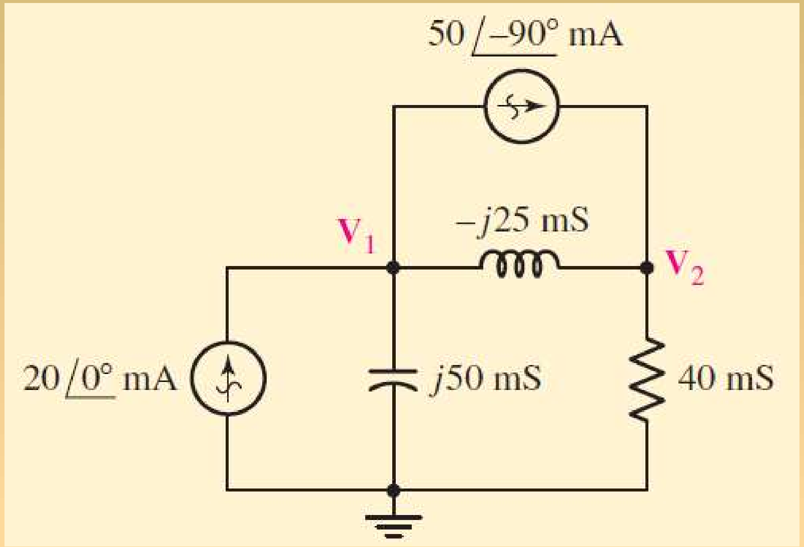
(ii) Use mesh analysis on the right-sided circuit to find I_1 and I_2.

Problem - 14



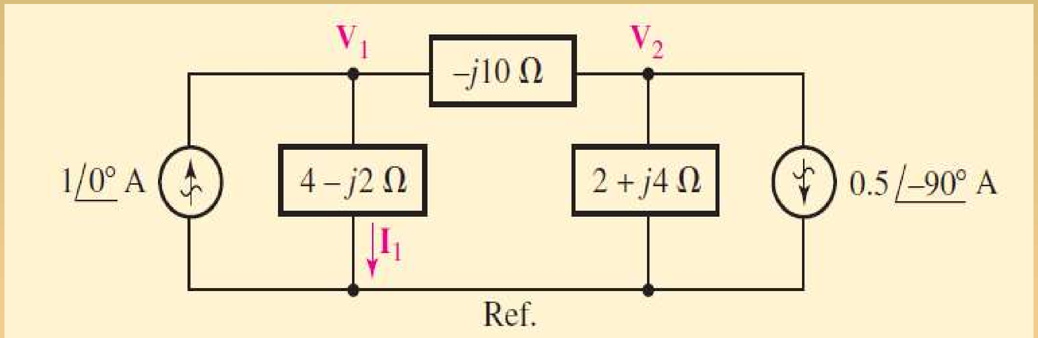
Use superposition to find V_1 for the circuit.

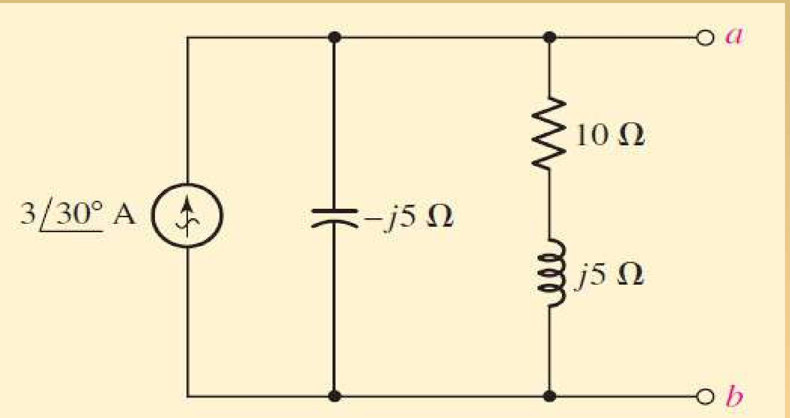
Problem - 15



If superposition is used on the circuit, find V_1 with (a) only the 20Ang(0°) mA source operating; (b) only the 50Ang(−90°) mA source operating.

Problem - 16

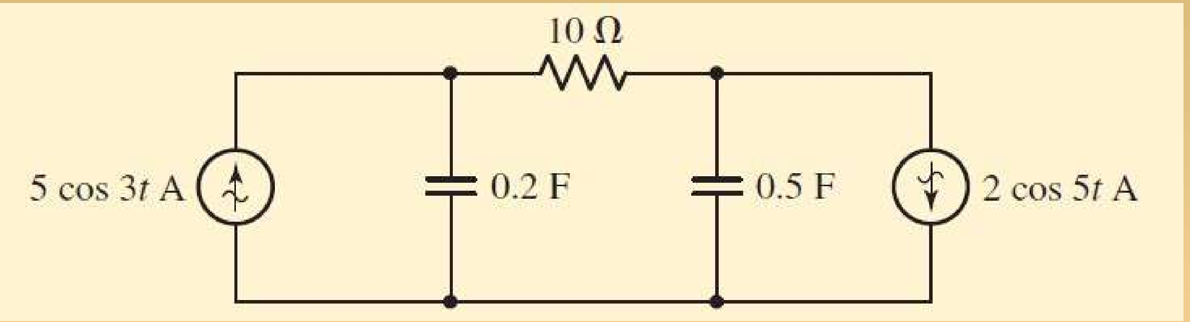




(i) For the left-sided circuit, determine the Thévenin equivalent seen by the −j10 Ohm impedance, and use this to compute V_1.

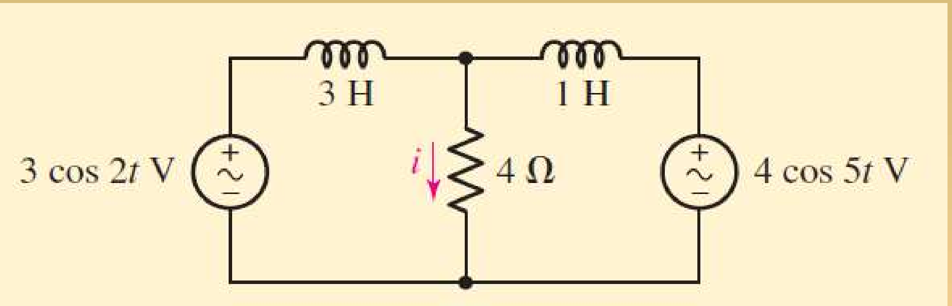
(ii) For the right-sided circuit, find the (a) open-circuit voltage V_{ab}; (b) downward current in a short circuit between a and b; (c) Thévenin equivalent impedance Z_{ab} in parallel with the current source.

Problem - 17



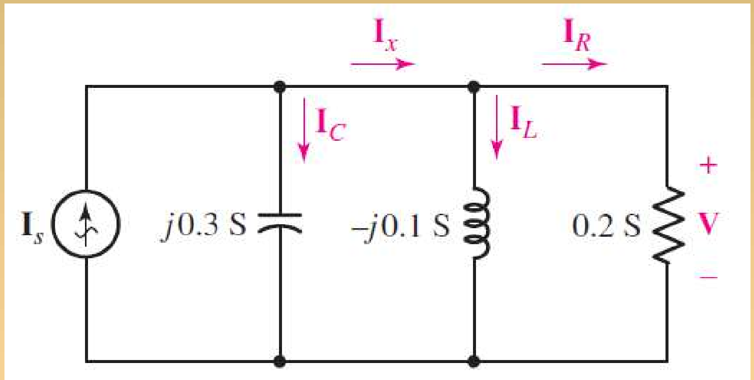
Determine the power dissipated by the 10 Ohm resistor in the circuit.

Problem - 18



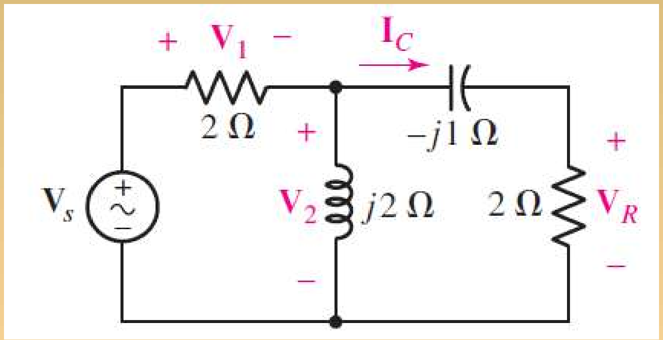
Determine the current i through the 4 Ohm resistor.

Problem - 19



Construct a phasor diagram showing I_R, I_L, and I_C for the circuit. Combining these currents, determine the angle by which I_s leads I_R, I_C, and I_x.

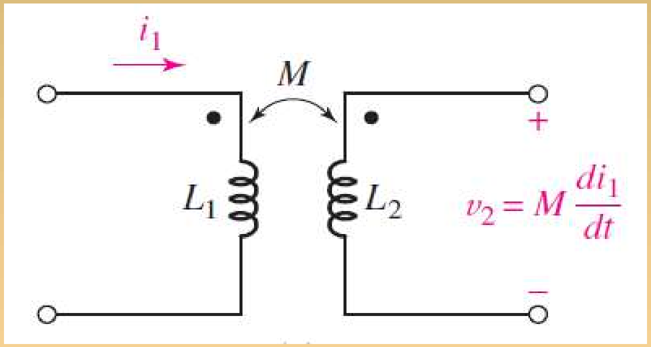
Problem - 20

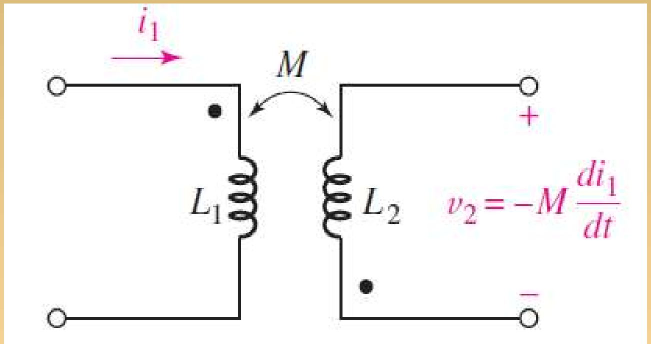


Select some convenient reference value for I_C in the circuit; draw a phasor diagram showing V_R, V_2, V_1, and V_s; and measure the ratio of the lengths of (a) V_s to V_1; (b) V_1 to V_2; (c) V_s to V_R.

Mutual Inductance, RL & RC Circuits, Phasors and Bode Plots

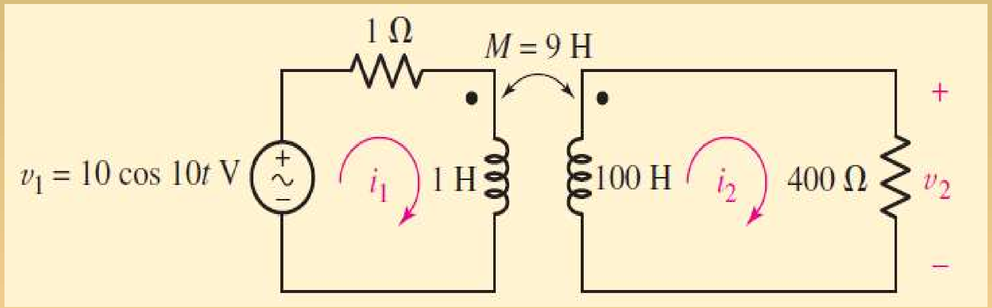
Problem - 1

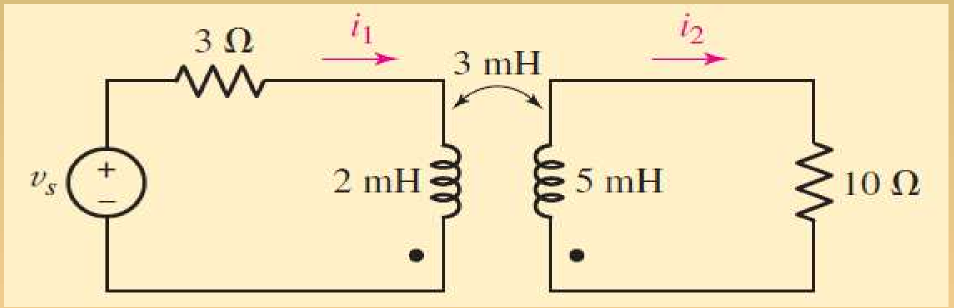




Assuming M = 10 H, coil L_2 is open-circuited, and $i_1 = -2e^{-5t}$ A, find the voltage v_2 for (a) left-sided and (b) right-sided networks.

Problem - 2

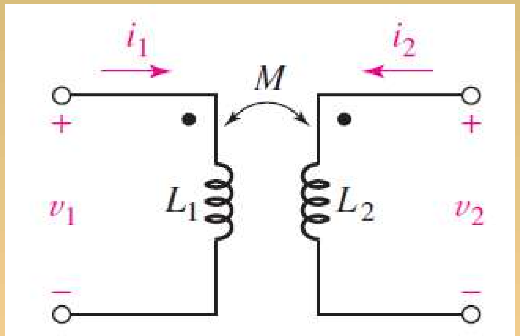


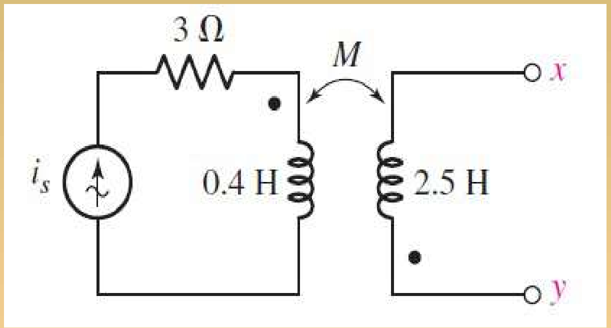


(i) For the left-sided circuit, find the ratio of the output voltage across the 400 Ohm resistor to the source voltage, expressed using phasor notation.

(ii) For the right-sided circuit, write an appropriate mesh equation in terms of the phasor currents I_1 and I_2 for the (a) left mesh; (b) right mesh.

Problem - 3

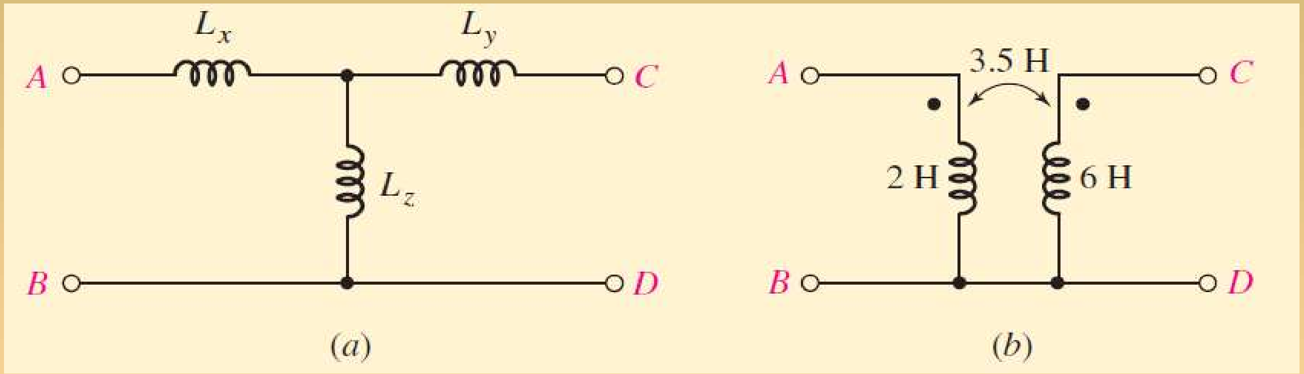




(i) In left-sided circuit, let $L_1 = 0.4$ H, $L_2 = 2.5$ H, $k = 0.6$, and $i_1 = 4i_2 = 20\cos(500t - 20^\circ)$ mA. Determine both $v_1(0)$ and the total energy stored in the system at $t = 0$.

(ii) If $i_s = 2\cos 10t$ A in the right-sided circuit, find the total energy stored in the passive network at $t = 0$ if $k = 0.6$ and terminals x and y are (a) left open-circuited; (b) short-circuited.

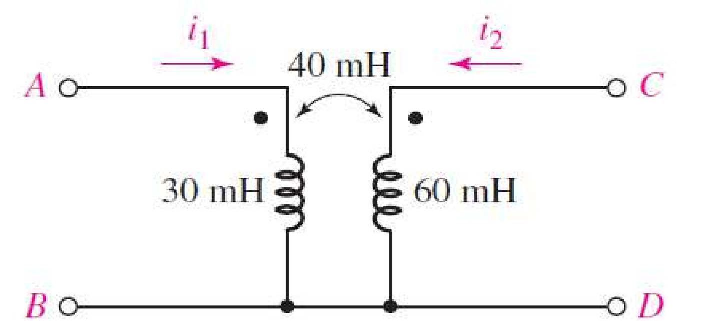
Problem - 4



(i) If the two networks of Figs. (a) and (b) are equivalent, specify values for L_x, L_y, and L_z.

(ii) Repeat if the dot on the secondary in Fig. (b) is located at the bottom of the coil.

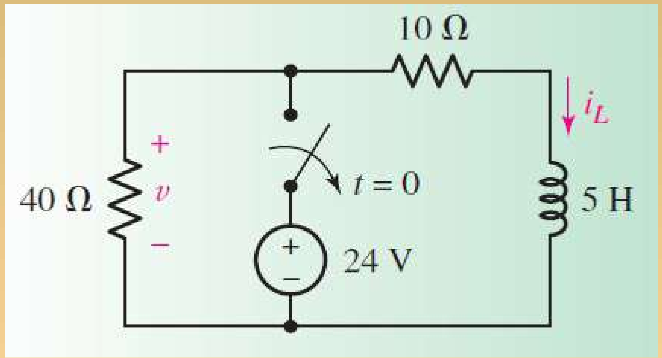
Problem - 5



(i) Find the T equivalent of the linear transformer.

(ii) Find the π-equivalent network of the transformer, assuming zero initial currents.

Problem - 6



(i) For the circuit, find the voltage labeled v at t = 200 ms.

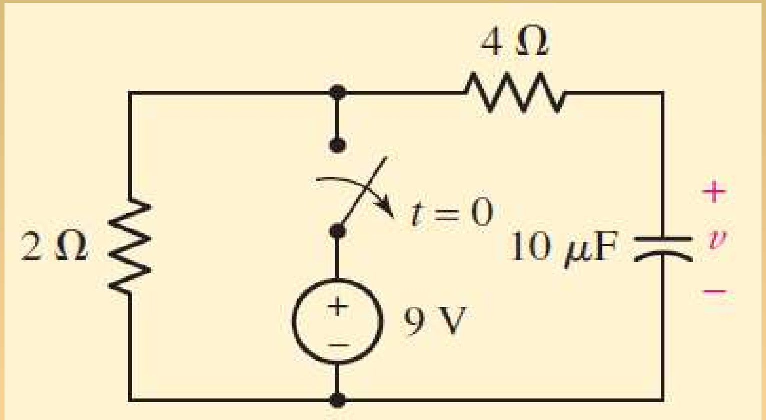
(ii) In a source-free series RL circuit, find the numerical value of the ratio: (a) $i(2\tau)/i(\tau)$;

(b) $i(0.5\tau)/i(0)$;

(c) t/τ if $i(t)/i(0) = 0.2$;

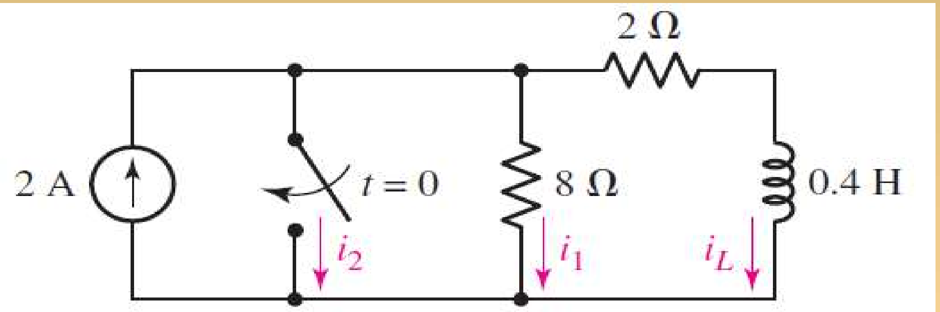
(d) t/τ if $i(0) - i(t) = i(0)\ln(2)$.

Problem - 7



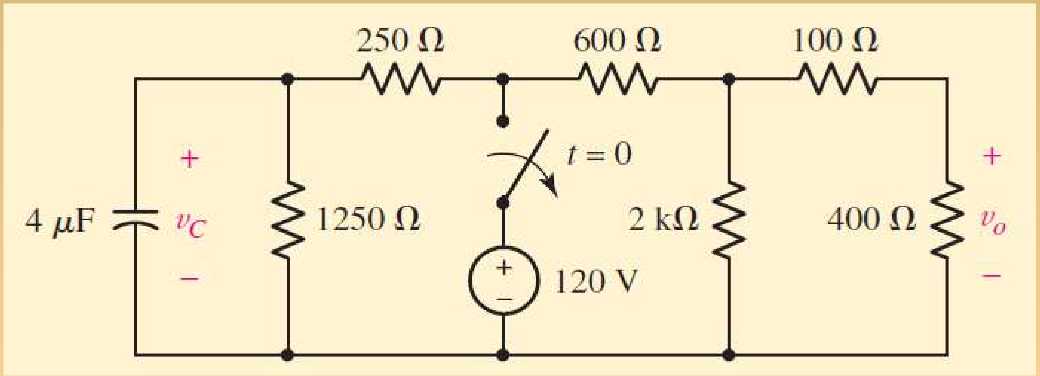
For the circuit, find the voltage labeled v at t = 200 μs.

Problem - 8



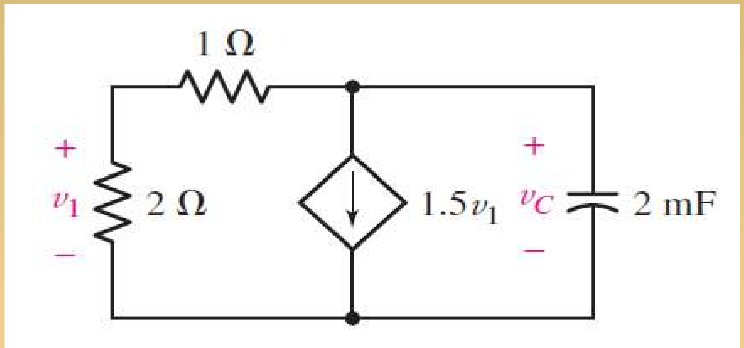
At t = 0.15 s in the circuit, find the value of (a) i_L; (b) i_1; (c) i_2.

Problem - 9



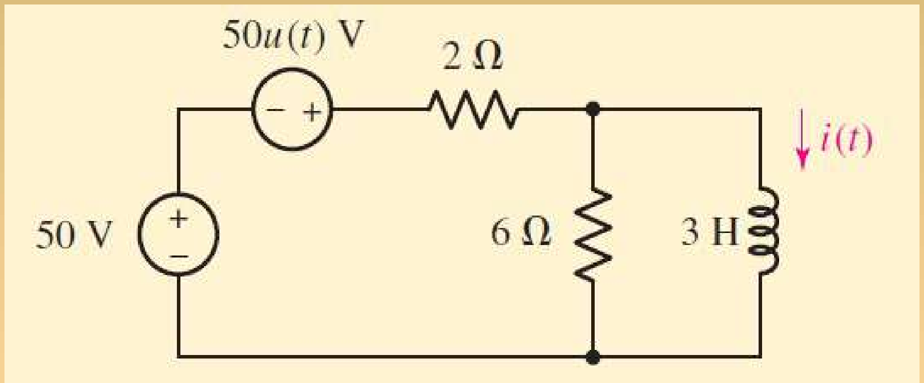
Find values of v_C and v_o in the circuit at t equal to (a) 0^-; (b) 0^+; (c) 1.3 ms.

Problem - 10



(a) For the circuit, determine the voltage $v_c(t)$ for $t > 0$ if $v_c(0^-) = 11$ V. (b) Is the circuit "stable"?

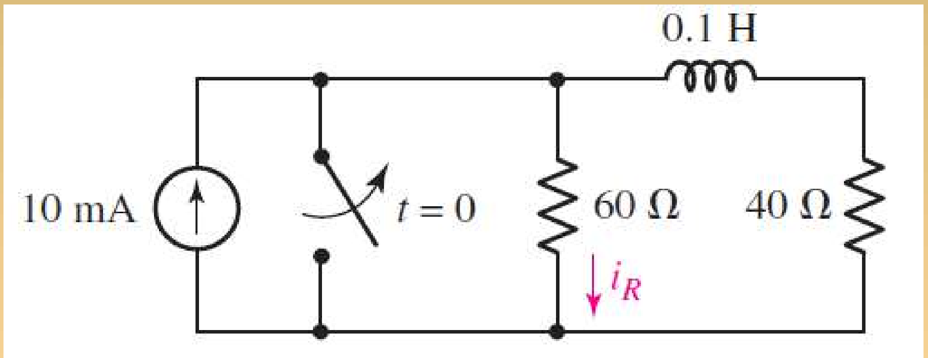
Problem - 11



(i) Determine i(t) for all values of time in the above circuit.

(ii) A voltage source, $v_s = 20u(t)$ V, is in series with a 200 Ohm resistor and a 4 H inductor. Find the magnitude of the inductor current at t equal to (a) 0^-; (b) 0^+; (c) 8 ms; (d) 15 ms.

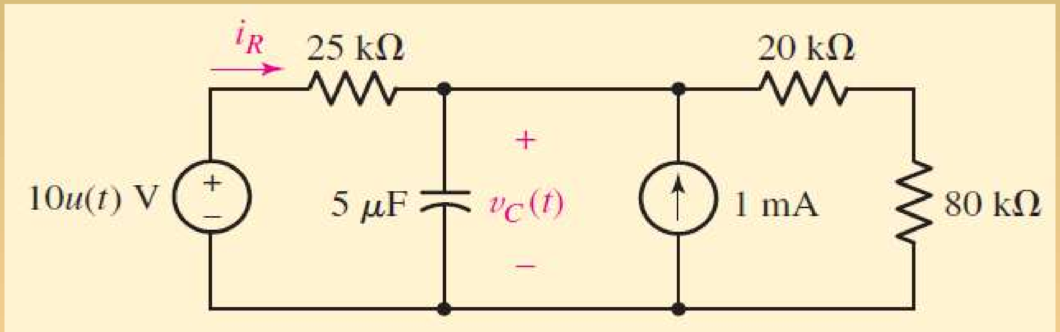
Problem - 12



(i) Find the current response in a simple series RL circuit when the forcing function is a rectangular voltage pulse of amplitude V_0 and duration t_0.

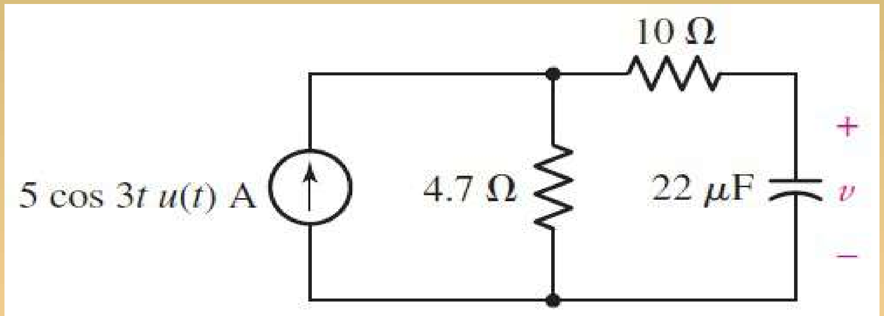
(ii) The above circuit has been in the form shown for a very long time. The switch opens at t = 0. Find i_R at t equal to (a) 0^-; (b) 0^+; (c) ∞; (d) 1.5 ms.

Problem - 13



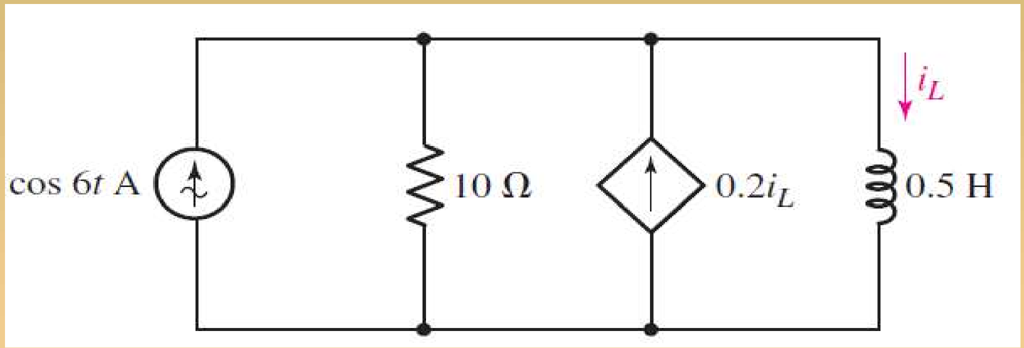
For the circuit, find $v_C(t)$ at t equal to (a) 0^-; (b) 0^+; (c) ∞; (d) 0.08 s.

Problem - 14



Determine the capacitor voltage v in the circuit for t > 0.

Problem - 15

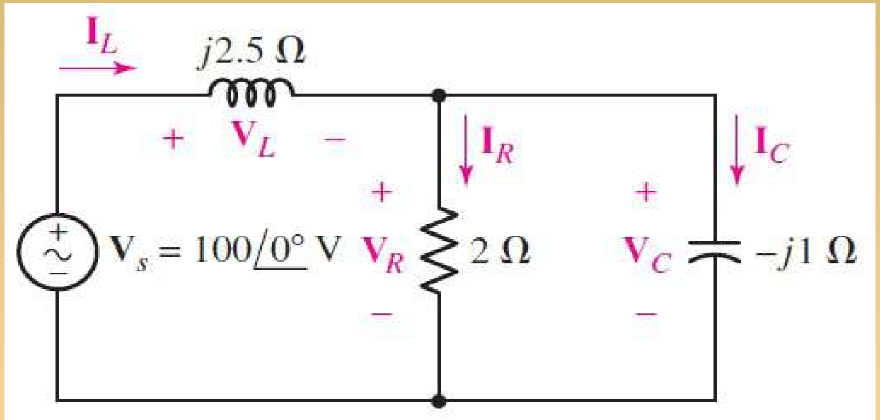


Obtain an expression for the power dissipated in the 10 Ohm resistor assuming no transients present.

Problem - 16

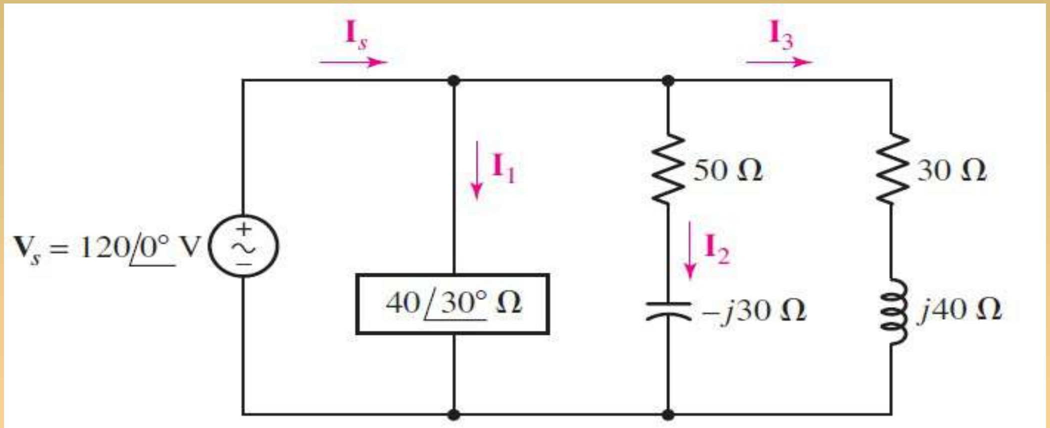
(a) A series connection is formed between a 1 Ohm resistor, a 1 F capacitor, and a 1 H inductor, in that order. Assuming operation at $\omega = 1$ rad/s, what are the magnitude and phase angle of the phasor current which yields a voltage of 1Ang(30°) V across the resistor (assume the passive sign convention)? (b) Compute the ratio of the phasor voltage across the resistor to the phasor voltage which appears across the capacitor-inductor combination. (c) The frequency is doubled. Calculate the new ratio of the phasor voltage across the resistor to the phasor voltage across the capacitor-inductor combination.

Problem - 17



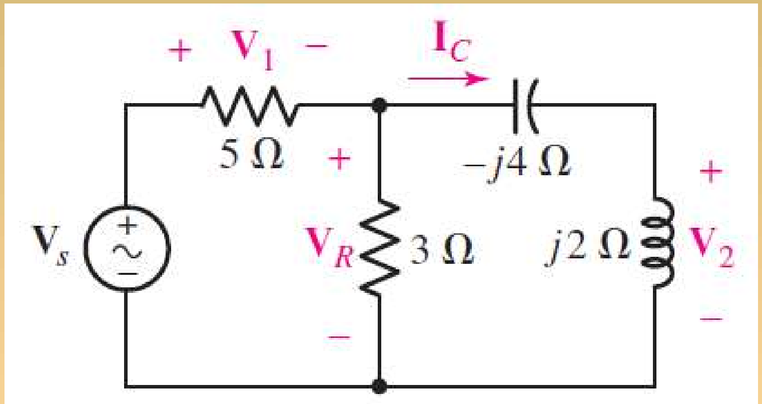
(a) Calculate values for I_L, I_R, I_C, V_L, V_R, and V_C for the circuit. (b) Using scales of 50 V to 1 in and 25 A to 1 in, show all seven quantities on a phasor diagram, and indicate that $I_L = I_R + I_C$ and $V_s = V_L + V_R$.

Problem - 18



In the circuit, (a) find values for I_1, I_2, and I_3. (b) Show V_s, I_1, I_2, and I_3 on a phasor diagram (scales of 50 V/in and 2 A/in work fine). (c) Find I_s graphically and give its amplitude and phase angle.

Problem - 19



The voltage source V_s is chosen such that $I_C = 1\text{Ang}(0^{\circ})$ A. (a) Draw a phasor diagram showing V_1, V_2, V_s, and V_R. (b) Use the diagram to determine the ratio of V_2 to V_1.

Problem - 20

Sketch the Bode magnitude and phase plots for the following functions:

(a) $3+4s$

(b) $\dfrac{1}{3+4s}$

(c) $25\left(1+\dfrac{s}{3}\right)\left(5+s\right)$

(d) $\dfrac{0.1}{\left(1+5s\right)\left(2+s\right)}$

AC Circuit Power Analysis

Problem - 1

(i) A voltage source, 40 + 60u(t) V, a 5 μF capacitor, and a 200 Ohm resistor form a series circuit. Find the power being absorbed by the capacitor and by the resistor at t = 1.2 ms.

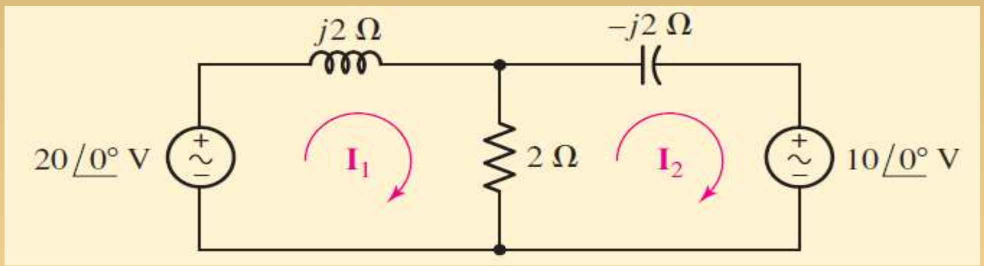
(ii) A current source of 12 cos 2000t A, a 200 Ohm resistor, and a 0.2 H inductor are in parallel. Assume steady-state conditions exist. At t = 1 ms, find the power being absorbed by the (a) resistor; (b) inductor; (c) sinusoidal source.

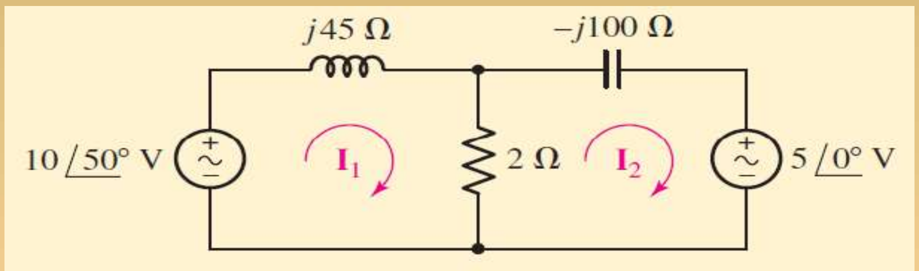
Problem - 2

(i) Given the time-domain voltage $v = 4 \cos(\pi t/6)$ V, find both the average power and an expression for the instantaneous power that result when the corresponding phasor voltage $V = 4\text{Ang}(0°)$ V is applied across an impedance $Z = 2\text{Ang}(60°)$ Ohm.

(ii) Given the phasor voltage $V = 115\sqrt{2}\text{Ang}(45°)$ V across an impedance $Z = 16.26\text{Ang}(19.3°)$ Ohm, obtain an expression for the instantaneous power, and compute the average power if $\omega = 50$ rad/s.

Problem - 3





(i) In the left-sided circuit, find the average power absorbed by each of the three passive elements, as well as the average power supplied by each source.

(ii) For the right-sided circuit, compute the average power delivered to each of the passive elements. Verify your answer by computing the power delivered by the two sources.

Problem - 4

(i) A particular circuit is composed of the series combination of a sinusoidal voltage source 3 cos(100t − 3°) V, a 500 Ohm resistor, a 30 mH inductor, and an unknown impedance. If we are assured that the voltage source is delivering maximum average power to the unknown impedance, what is its value?

(ii) If the 30 mH inductor of the above problem is replaced with a 10 μF capacitor, what is the value of the inductive component of the unknown impedance Z if it is known that Z is absorbing maximum power?

Problem - 5

(i) Find the average power delivered to a 4 Ohm resistor by the current (a) $i_1 = 2 \cos 10t - 3 \cos 20t$ A, (b) $i_2 = 2 \cos 10t - 3 \cos 10t$ A.

(ii) A voltage source v_s is connected across a 4 Ohm resistor. Find the average power absorbed by the resistor if v_s equals (a) $8 \sin 200t$ V; (b) $8 \sin 200t - 6 \cos(200t - 45^\circ)$ V; (c) $8 \sin 200t - 4 \sin 100t$ V; (d) $8 \sin 200t - 6 \cos(200t - 45^\circ) - 5 \sin 100t + 4$ V.

Problem - 6

Calculate the effective value of each of the periodic voltages:

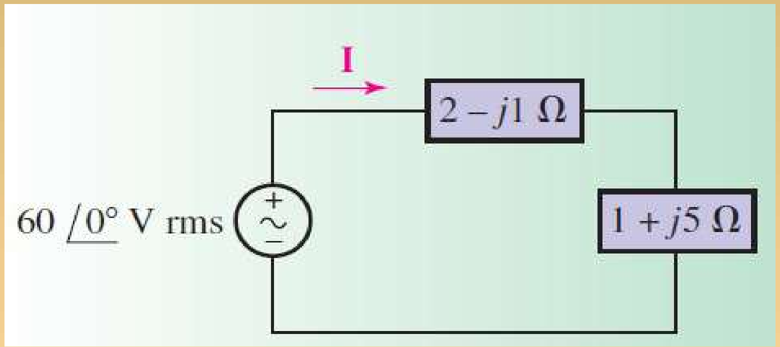
(a) $6 \cos 25t$ V;

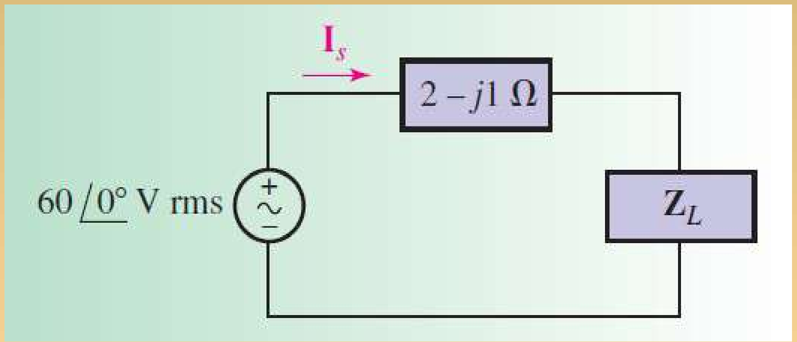
(b) $6 \cos 25t + 4 \sin(25t + 30^\circ)$ V;

(c) $6 \cos 25t + 5 \cos^2(25t)$ V;

(d) $6 \cos 25t + 5 \sin 30t + 4$ V.

Problem - 7





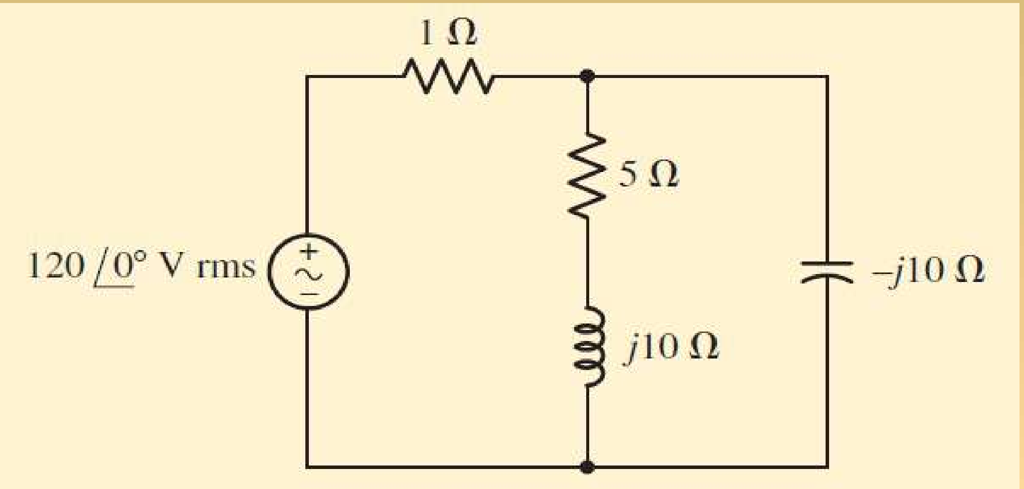
(i) For the left-sided circuit, calculate values for the average power delivered to each of the two loads, the apparent power supplied by the source, and the power factor of the combined loads.

(ii) For the right-sided circuit, determine the power factor of the combined loads if Z_L = 10 Ohm.

Problem - 8

An industrial consumer is operating a 50 kW (67.1 hp) induction motor at a lagging PF of 0.8. The source voltage is 230 V rms. In order to obtain lower electrical rates, the customer wishes to raise the PF to 0.95 lagging. Specify a suitable solution.

Problem - 9



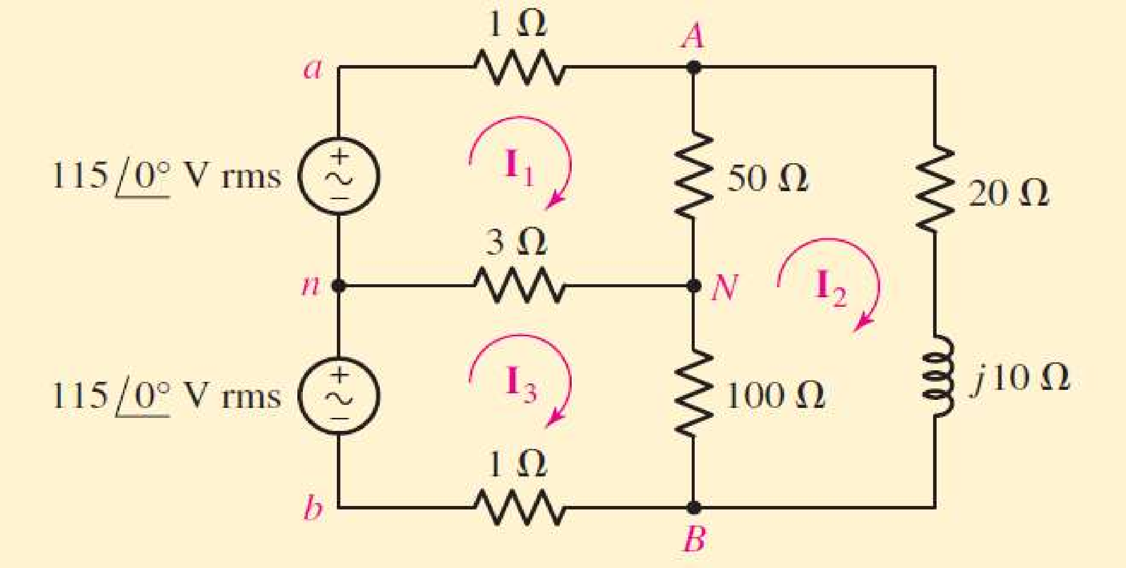
For the circuit, find the complex power absorbed by the (a) 1 Ohm resistor; (b) −j10 Ohm capacitor; (c) 5 + j10 Ohm impedance; (d) source.

Problem - 10

A 440 V rms source supplies power to a load $Z_L = 10 + j2$ Ohm through a transmission line having a total resistance of 1.5 Ohm. Find (a) the average and apparent power supplied to the load; (b) the average and apparent power lost in the transmission line; (c) the average and apparent power supplied by the source; (d) the power factor at which the source operates.

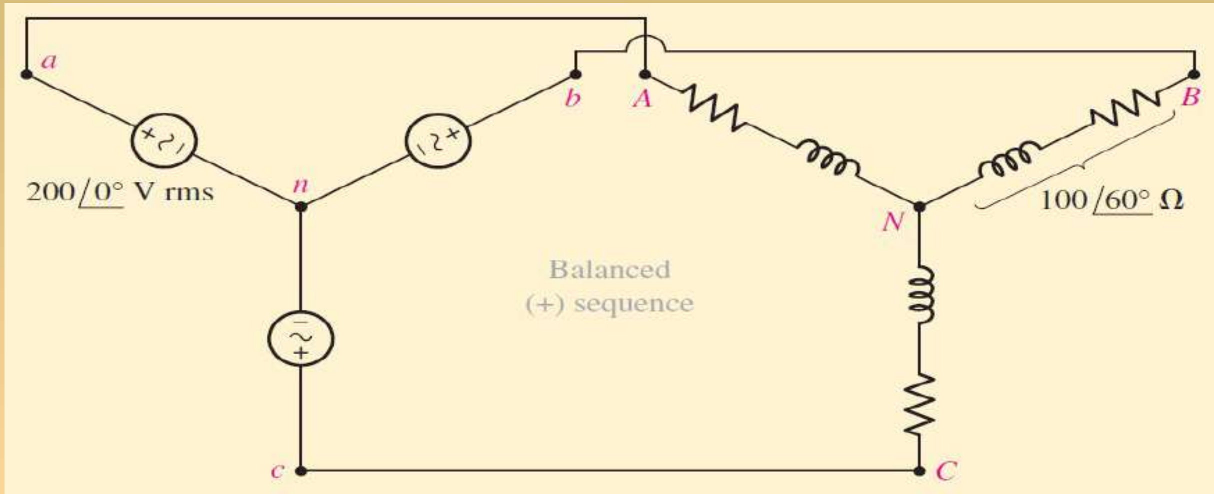
Polyphase Circuits

Problem - 1



Analyze the typical single-phase three wire system shown above and determine the power delivered to each of the three loads as well as the power lost in the neutral wire and each of the two lines.

Problem - 2



(i) For the above circuit, find both the phase and line currents, and the phase and line voltages throughout the circuit; then calculate the total power dissipated in the load.

(ii) A balanced three-phase three-wire system has a Y-connected load. Each phase contains three loads in parallel: −j100 Ω, 100 Ω, and 50 + j50Ω. Assume positive phase sequence with $\mathbf{V}_{ab}$ = 400Ang(0°) V. Find (a) $\mathbf{V}_{an}$; (b) $\mathbf{I}_{aA}$; (c) the total power drawn by the load.

Problem - 3

(i) A balanced three-phase system with a line voltage of 300 V is supplying a balanced Y-connected load with 1200 W at a leading PF of 0.8. Find the line current and the per-phase load impedance. A balanced 600 W lighting load is added (in parallel) to this system. Determine the new line current.

(ii) A balanced three-phase three-wire system has a line voltage of 500 V. Two balanced Y-connected loads are present. One is a capacitive load with $7 - j2\ \Omega$ per phase, and the other is an inductive load with $4 + j2\ \Omega$ per phase. Find (a) the phase voltage; (b) the line current; (c) the total power drawn by the load; (d) the power factor at which the source is operating.

Problem - 4

Three balanced Y-connected loads are installed on a balanced three-phase four-wire system. Load 1 draws a total power of 6 kW at unity PF, load 2 pulls 10 kVA at PF= 0.96 lagging, and load 3 demands 7 kW at 0.85 lagging. If the phase voltage at the loads is 135 V, if each line has a resistance of 0.1 Ω, and if the neutral has a resistance of 1 Ω, find (a) the total power drawn by the loads; (b) the combined PF of the loads; (c) the total power lost in the four lines; (d) the phase voltage at the source; (e) the power factor at which the source is operating.

Problem - 5

(i) Determine the amplitude of the line current in a three-phase system with a line voltage of 300 V that supplies 1200 W to a Delta-connected load at a lagging PF of 0.8; then find the phase impedance.

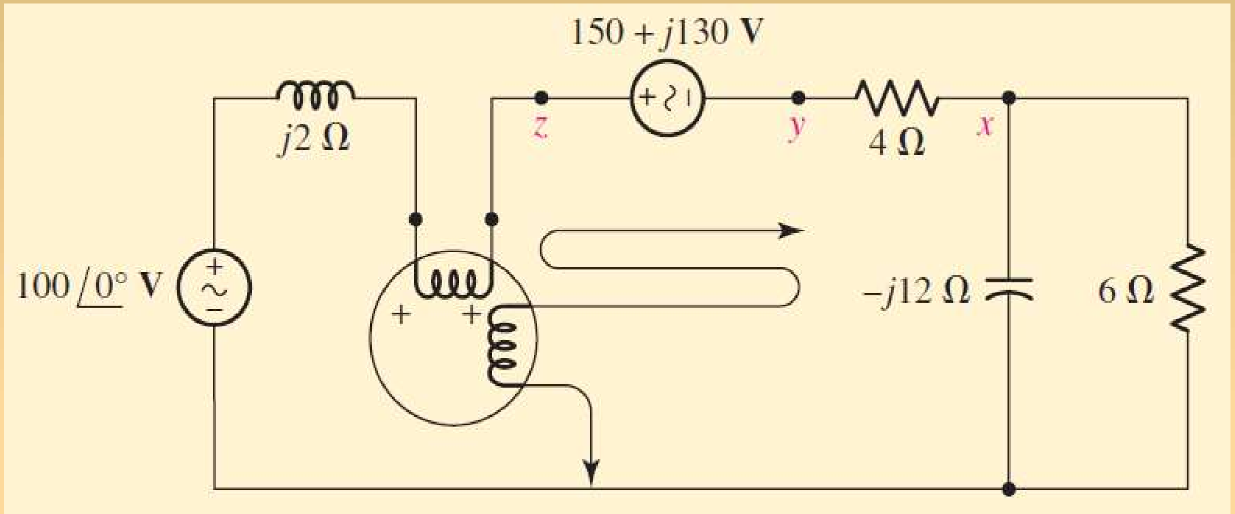
(ii) Each phase of a balanced three-phase Delta-connected load consists of a 200 mH inductor in series with the parallel combination of a 5 μF capacitor and a 200 Ω resistance. Assume zero line resistance and a phase voltage of 200 V at ω = 400 rad/s. Find (a) the phase current; (b) the line current; (c) the total power absorbed by the load.

Problem - 6

(i) Determine the amplitude of the line current in a three-phase system with a 300 V line voltage that supplies 1200 W to a Y-connected load at a lagging PF of 0.8.

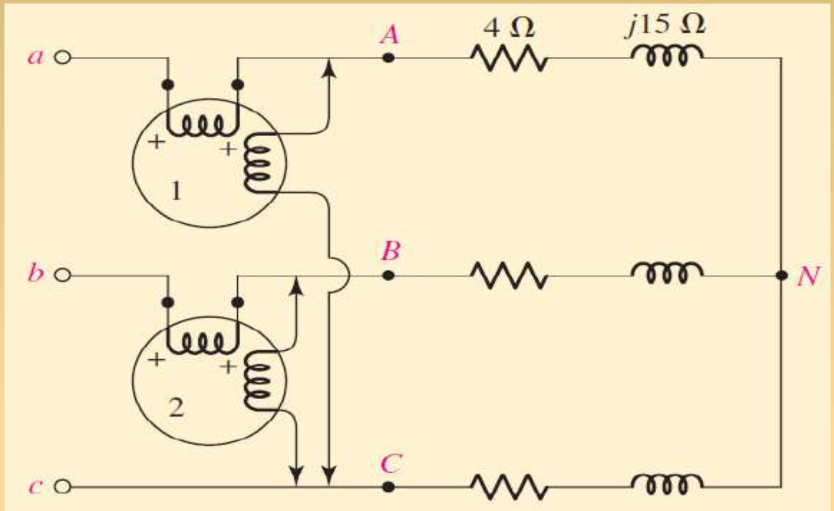
(ii) A balanced three-phase three-wire system is terminated with two Delta-connected loads in parallel. Load 1 draws 40 kVA at a lagging PF of 0.8, while load 2 absorbs 24 kW at a leading PF of 0.9. Assume no line resistance, and let $\mathbf{V}_{ab}$ = 440Ang(30°) V. Find (a) the total power drawn by the loads; (b) the phase current $\mathbf{I}_{AB1}$ for the lagging load; (c) $\mathbf{I}_{AB2}$; (d) $\mathbf{I}_{aA}$.

Problem - 7



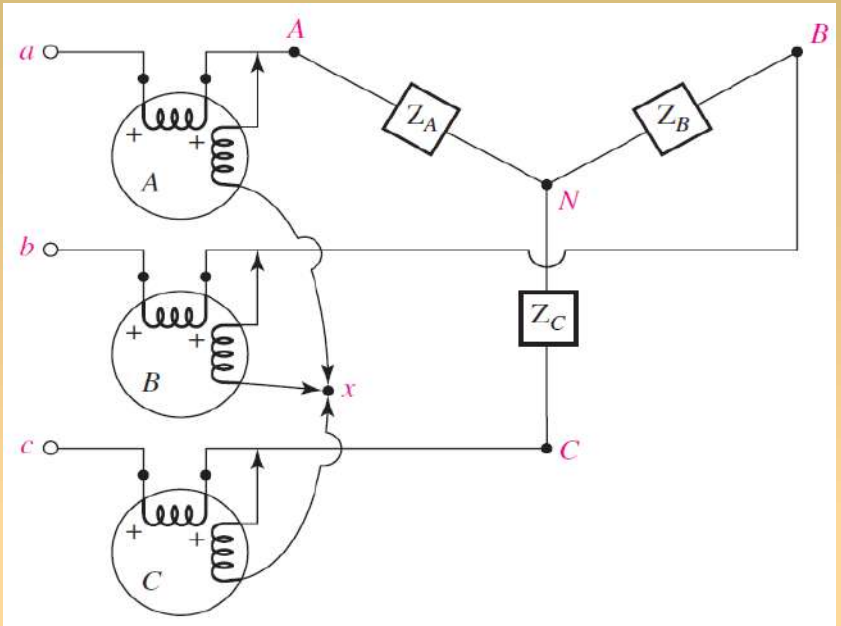
Determine the wattmeter reading in the above Figure, state whether or not the potential coil had to be reversed in order to obtain an upscale reading, and identify the device or devices absorbing or generating this power. The (+) terminal of the wattmeter is connected to (a) x; (b) y; (c) z.

Problem - 8



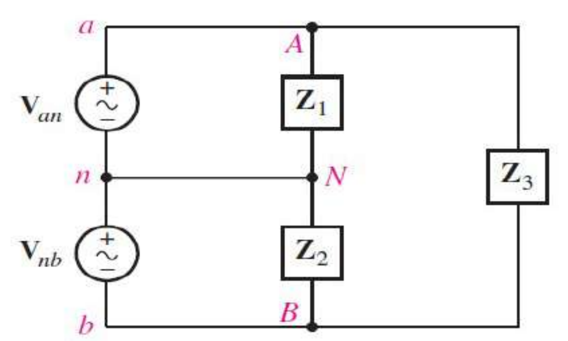
The balanced load in the circuit is fed by a balanced three-phase system having $\mathbf{V}_{ab}$ = 230Ang(0°) V rms and positive phase sequence. Find the reading of each wattmeter and the total power drawn by the load.

Problem - 9



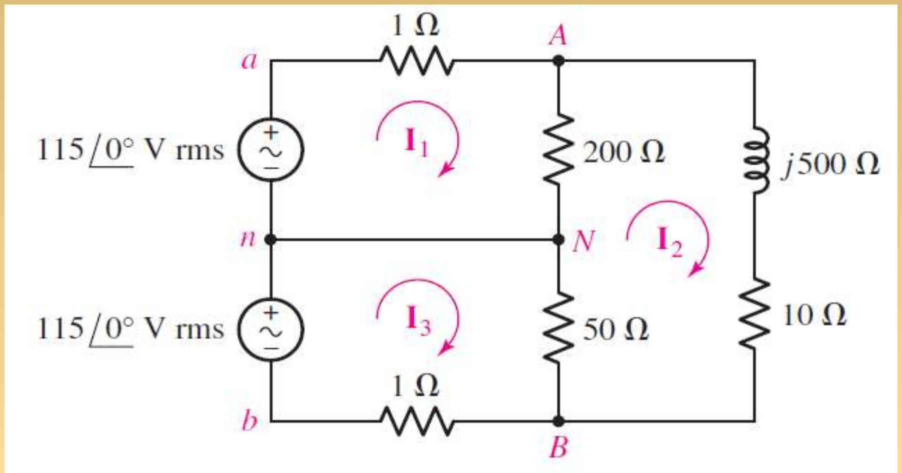
For the circuit, let the loads be $\mathbf{Z}_A = 25\text{Ang}(60^\circ)\ \Omega$, $\mathbf{Z}_B = 50\text{Ang}(-60^\circ)\ \Omega$, $\mathbf{Z}_C = 50\text{Ang}(60^\circ)\ \Omega$, $\mathbf{V}_{AB} = 600\text{Ang}(0^\circ)$ V rms with (+) phase sequence, and locate point x at C. Find (a) P_A; (b) P_B; (c) P_C.

Problem - 10



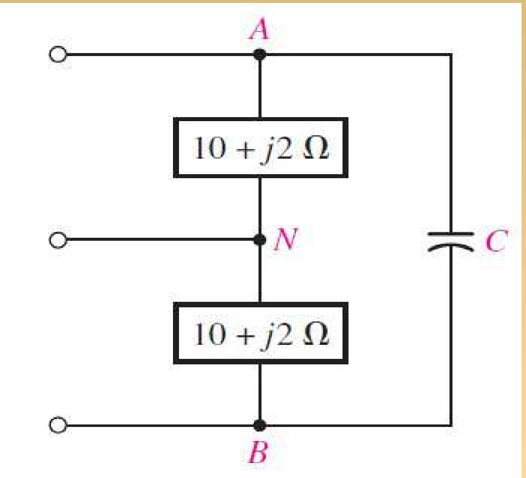
The single-phase three-wire system has three separate load impedances. If the source is balanced and $\mathbf{V}_{an}$ = 110 + j0 V rms, (a) express $\mathbf{V}_{an}$ and V_{bn} in phasor notation. (b) Determine the phasor voltage which appears across the impedance $\mathbf{Z}_3$. (c) Determine the average power delivered by the two sources if $\mathbf{Z}_1 = 50 + j0\ \Omega$, $\mathbf{Z}_2 = 100 + j45\ \Omega$, and $\mathbf{Z}_3 = 100 - j90\ \Omega$. (d) Represent load $\mathbf{Z}_3$ by a series connection of two elements, and state their respective values if the sources operate at 60 Hz.

Problem - 11



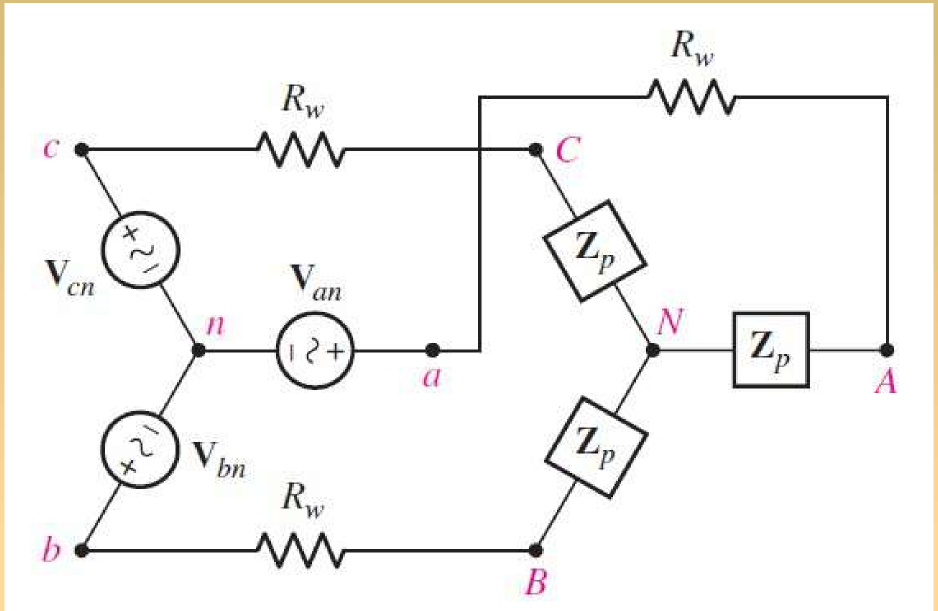
For the system, the ohmic losses in the neutral wire are so small they can be neglected and it can be adequately modeled as a short circuit. (a) Calculate the power lost in the two lines as a result of their nonzero resistance. (b) Compute the average power delivered to the load. (c) Determine the power factor of the total load.

Problem - 12



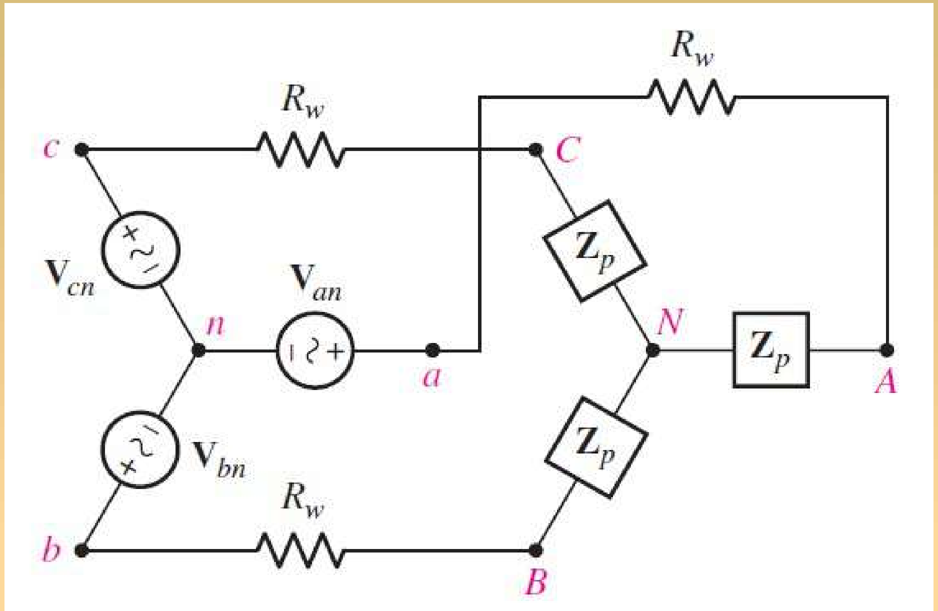
Referring to the balanced load, if it is connected to a three-wire balanced source operating at 50 Hz such that V_{AN} = 115 V, (a) determine the power factor of the load if the capacitor is omitted; (b) determine the value of capacitance C that will achieve a unity power factor for the total load.

Problem - 13



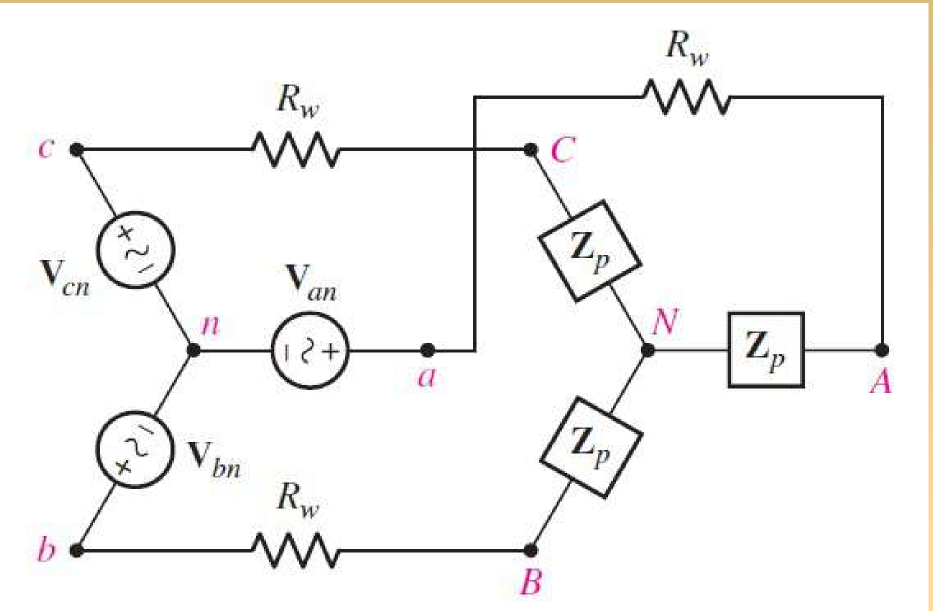
Assume the system is balanced, $R_w = 0$, $\mathbf{V}_{an} = 208\text{Ang}(0^\circ)$ V, and a positive phase sequence applies. Calculate all phase and line currents, and all phase and line voltages, if $\mathbf{Z}_p$ is equal to (a) 1 kΩ; (b) 100 + j48 Ω; (c) 100 − j48 Ω.

Problem - 14



With the assumption that the three-phase system is balanced with a line voltage of 100 V, calculate the line current and per-phase load impedance if R_w = 0 and the load draws (a) 1 kW at a PF of 0.85 lagging; (b) 300 W per phase at a PF of 0.92 leading.

Problem - 15



The balanced three-phase system is characterized by a positive phase sequence and a line voltage of 300 V. And $\mathbf{Z}_p$ is given by the parallel combination of a 5 − j3 Ω capacitive load and a 9 + j2 Ω inductive load. If R_w = 0, calculate (a) the power factor of the source; (b) the total power supplied by the source. (c) Repeat parts (a) and (b) if R_w = 1 Ω.

Problem - 16

A particular balanced three-phase system is supplying a Delta-connected load with 10 kW at a leading power factor of 0.7. If the phase voltage is 208 V and the source operates at 50 V, (a) compute the line current; (b) determine the phase impedance; (c) calculate the new power factor and new total power delivered to the load if a 2.5 H inductor is connected in parallel with each phase of the load.

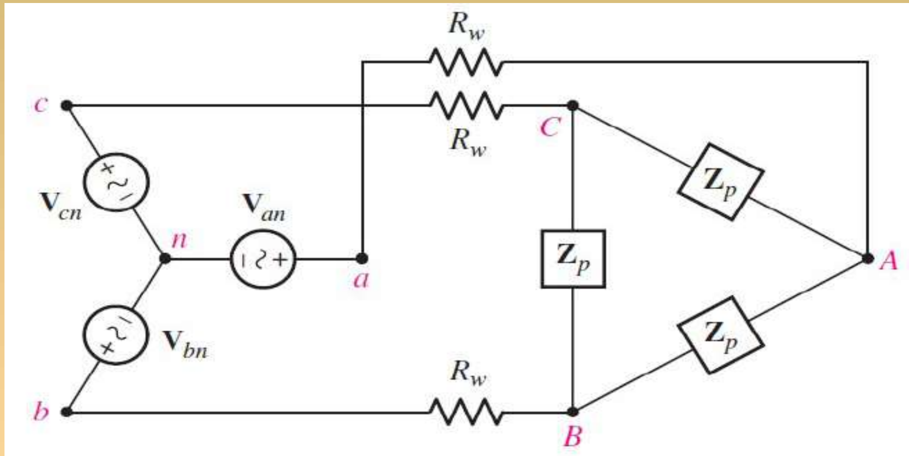
Problem - 17

If each of the three phases in a balanced Delta-connected load is composed of a 10 mF capacitor in parallel with a series-connected 470 Ω resistor and 4 mH inductor combination, assume a phase voltage of 400 V at 50 Hz. (a) Calculate the phase current; (b) the line current; (c) the line voltage; (d) the power factor at which the source operates; (e) the total power delivered to the load.

Problem - 18

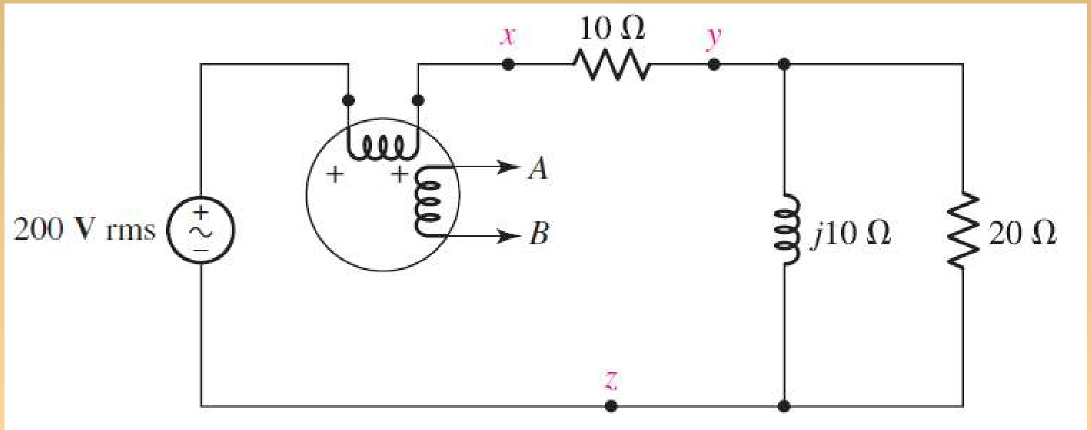
Two Delta-connected loads are connected in parallel and powered by a balanced Y-connected system. The smaller of the two loads draws 10 kVA at a lagging PF of 0.75, and the larger draws 25 kVA at a leading PF of 0.80. The line voltage is 400 V. Calculate (a) the power factor at which the source is operating; (b) the total power drawn by the two loads; (c) the phase current of each load.

Problem - 19



For the balanced three-phase system, it is determined that 100 W is lost in each wire. If the phase voltage of the source is 400 V, and the load draws 12 kW at a lagging PF of 0.83, determine the wire resistance R_w.

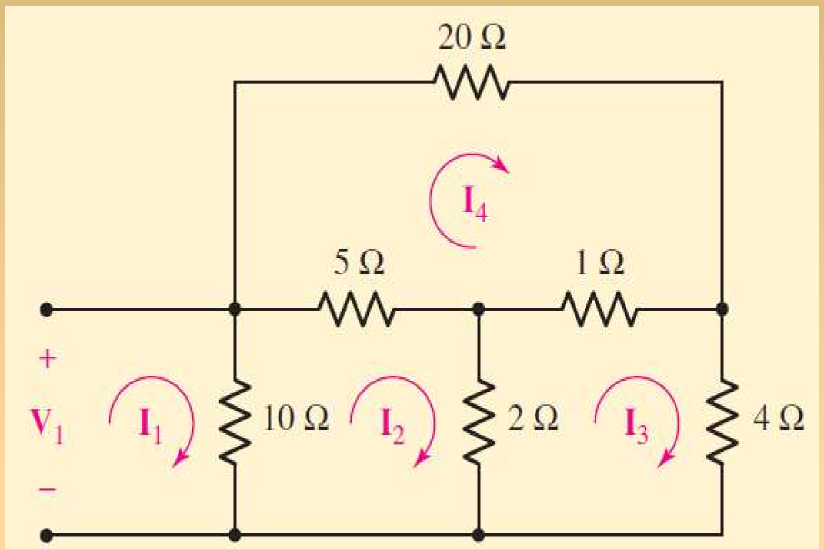
Problem - 20

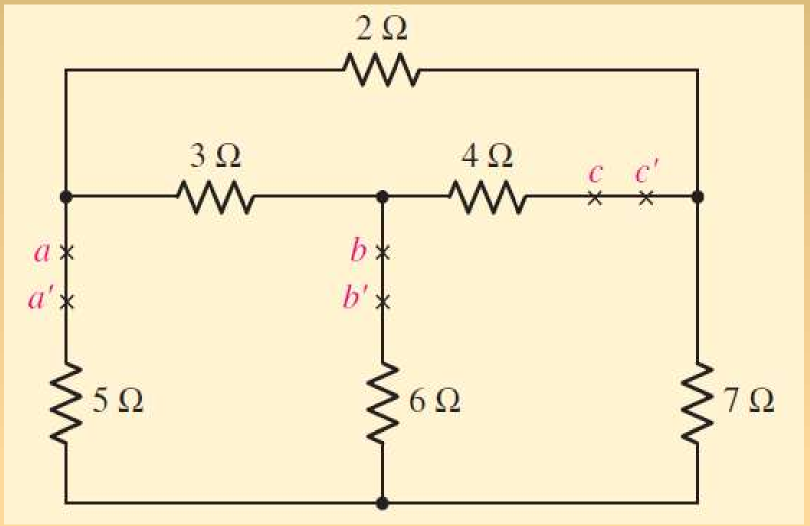


Determine the wattmeter reading (stating whether or not the leads had to be reversed to obtain it) in the circuit if terminals A and B, respectively, are connected to (a) x and y; (b) x and z; (c) y and z.

Two-port Networks

Problem - 1

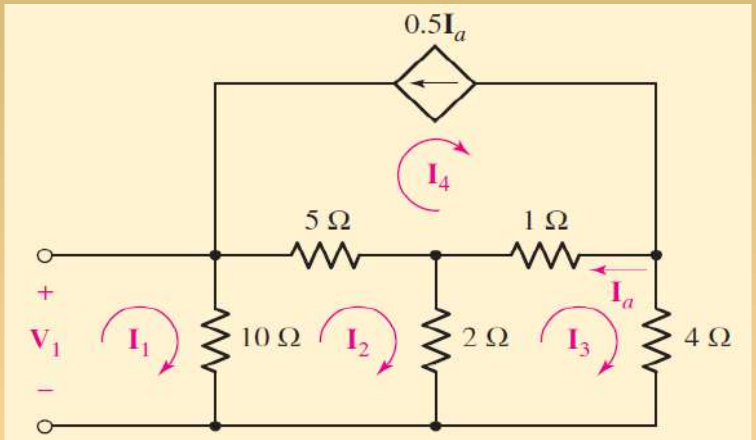


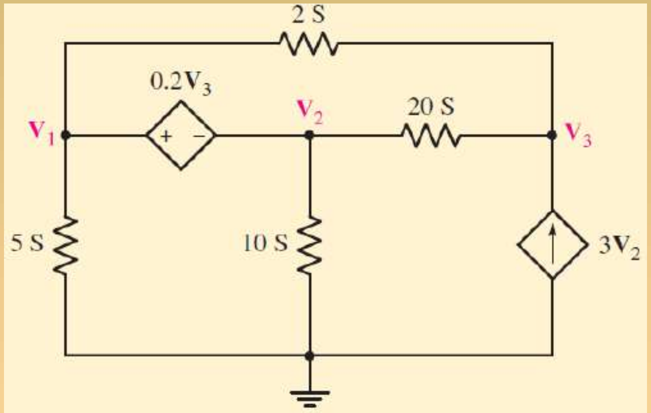


(i) Calculate the input impedance for the one-port resistive network given in left.

(ii) Find the input impedance of the network shown in right if it is formed into a one-port network by breaking it at terminals (a) a and a'; (b) b and b'; (c) c and c'.

Problem - 2

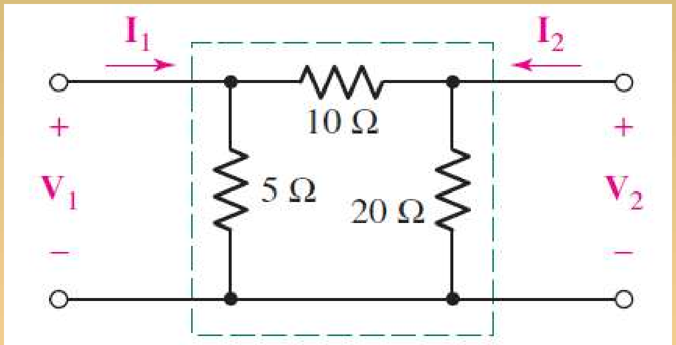


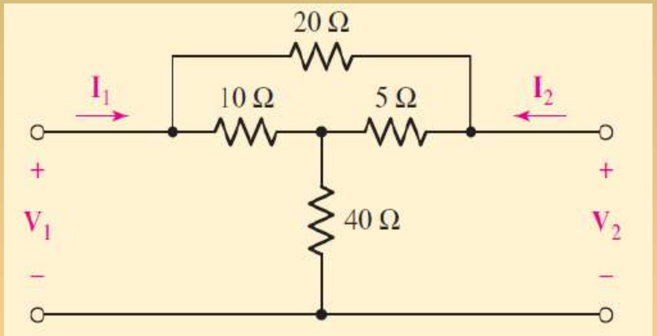


(i) Find the input impedance of the left-sided network.

(ii) Write a set of nodal equations for the right-sided circuit, calculate Δ_Y, and then find the input admittance seen between (a) node 1 and the reference node; (b) node 2 and the reference.

Problem - 3

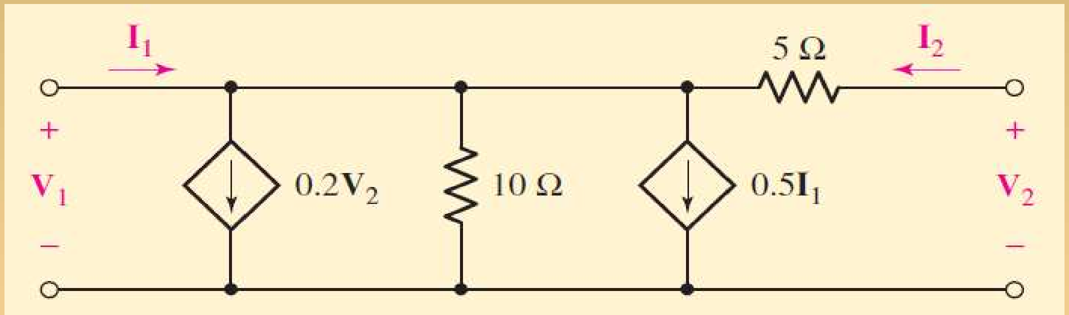




(i) Find the four short-circuit admittance parameters for the resistive two-port given in left.

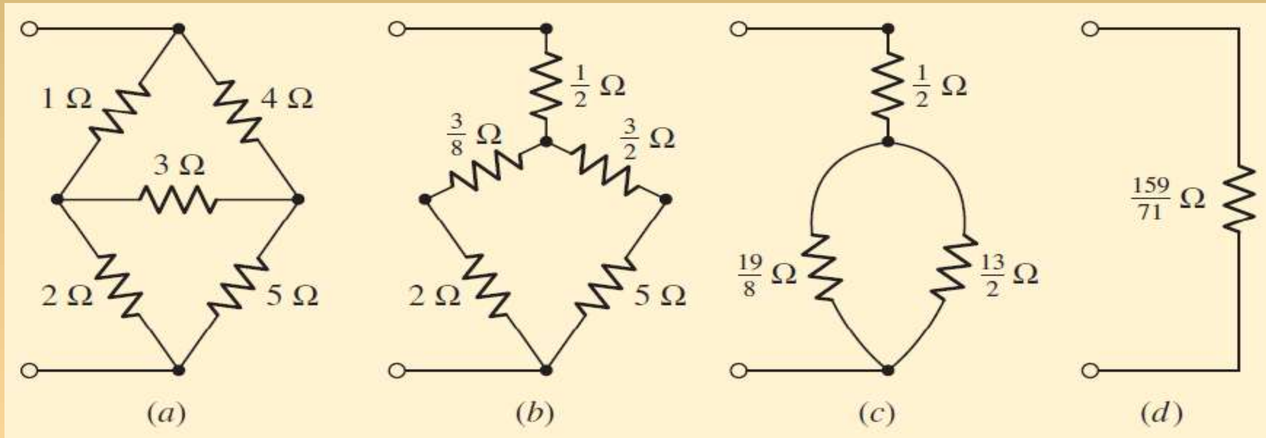
(ii) By applying the appropriate 1 V sources and short circuits to the right-sided circuit, find (a) y_{11}; (b) y_{21}; (c) y_{22}; (d) y_{12}.

Problem - 4



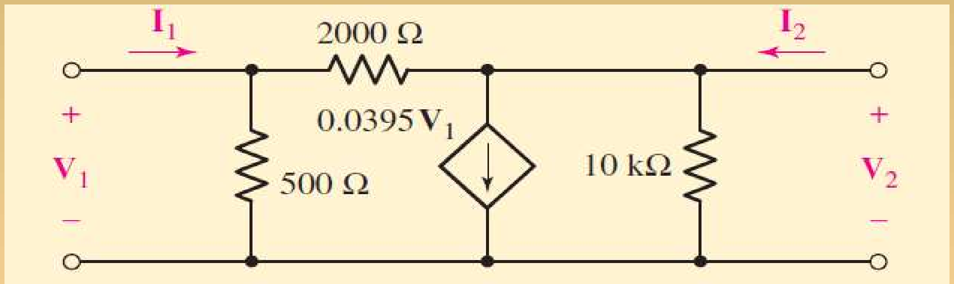
Find y for the two-port.

Problem - 5



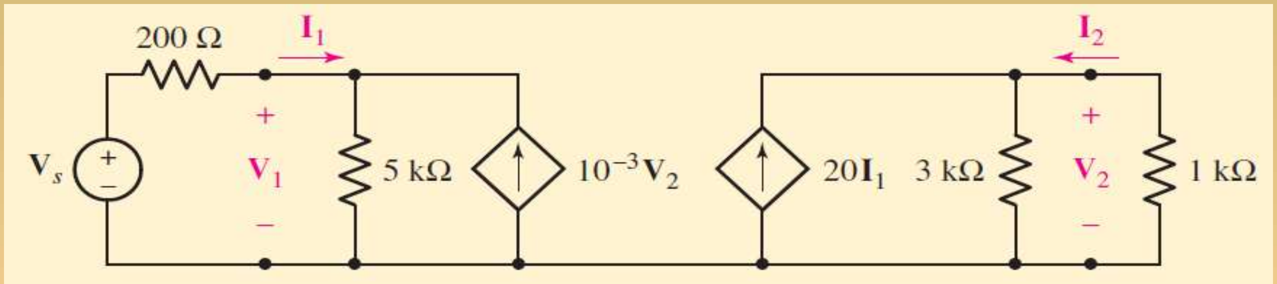
Find the input resistance of the circuit.

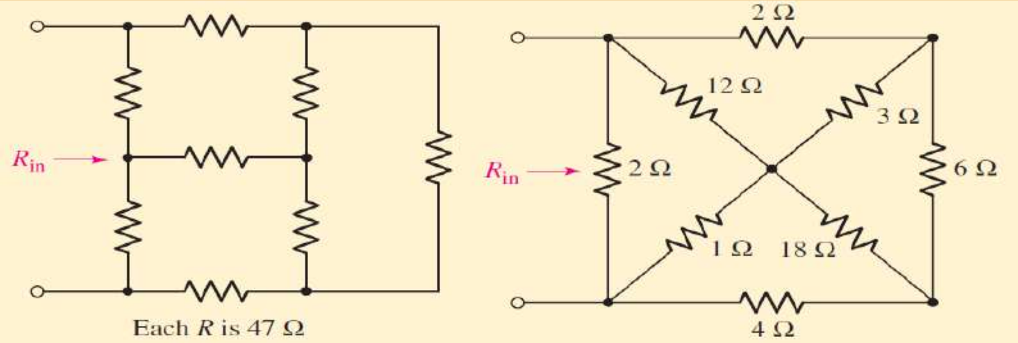
Problem - 6



The circuit shown here is an approximate linear equivalent of a transistor amplifier in which the emitter terminal is the bottom node, the base terminal is the upper input node, and the collector terminal is the upper output node. A 2000 Ω resistor is connected between collector and base for some special application and makes the analysis of the circuit more difficult. Determine the y parameters for this circuit.

Problem - 7





(i) Find **y** and Z_{out} for the terminated two-port (upper figure).

(ii) Use Δ-Y and Y-Δ transformations to determine R_{in} for the network shown in (a) bottom left; (b) bottom-right.

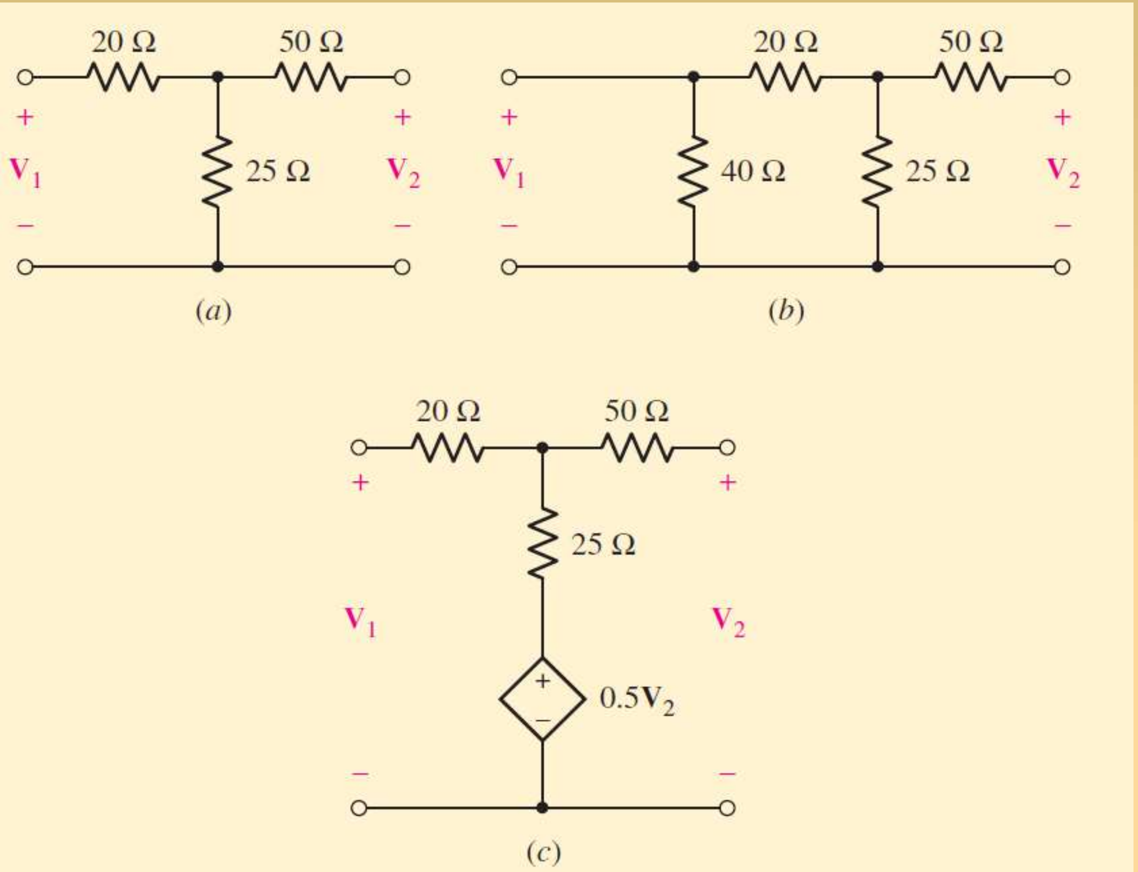
Problem - 8

Given the set of impedance parameters

$$\mathbf{z} = \begin{bmatrix} 10^3 & 10 \\ -10^6 & 10^4 \end{bmatrix}$$ (all in Ω)

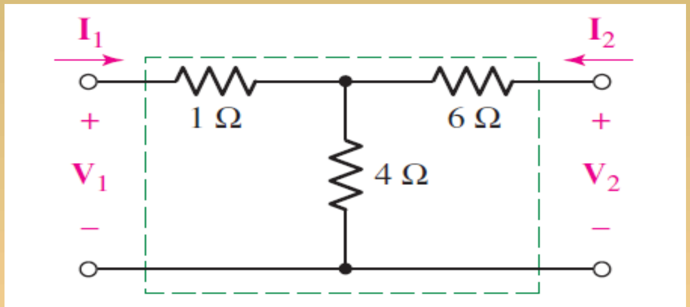
which is representative of a bipolar junction transistor operating in the common-emitter configuration, determine the voltage, current, and power gains, as well as the input and output impedances. The two-port is driven by an ideal sinusoidal voltage source V_s in series with a 500 Ω resistor, and terminated in a 10 kΩ load resistor.

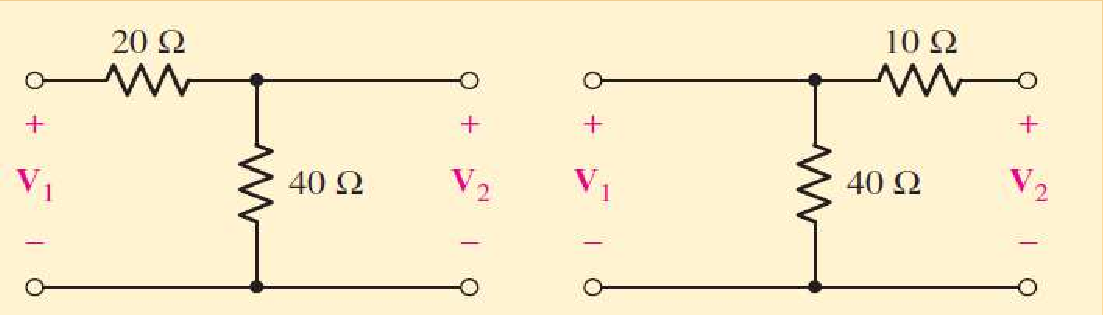
Problem - 9



Find **z** for the two-port shown in (a) Fig. a; (b) Fig. b. (c) Fig. c.

Problem - 10

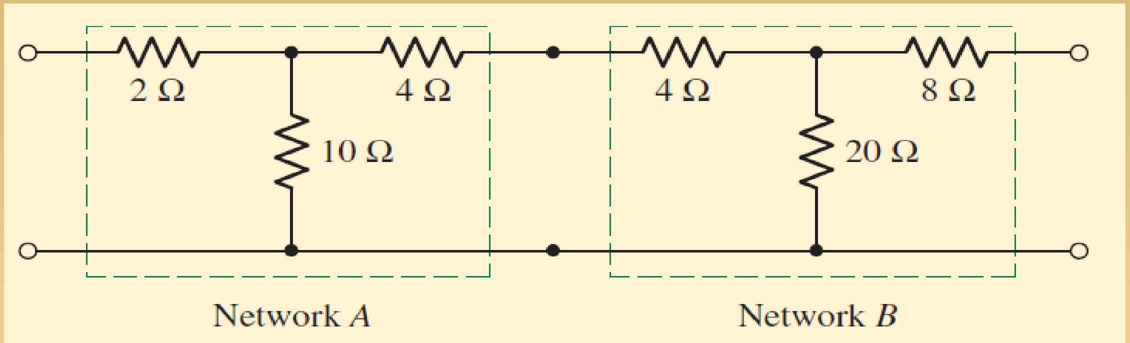




(i) Find **h** for the bilateral resistive circuit (upper figure).

(ii) Find **h** for the two-port shown in (a) bottom-left, (b) bottom-right.

Problem - 11



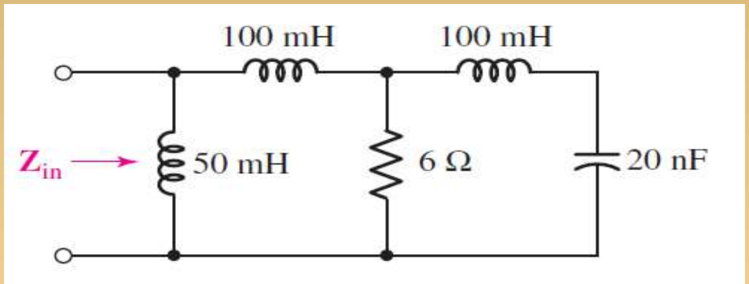
(i) Find the **t** parameters for the cascaded networks.

(ii) Given

$$\mathbf{t} = \begin{bmatrix} 3.2 & 8\ \Omega \\ 0.2\ \text{S} & 4 \end{bmatrix}$$

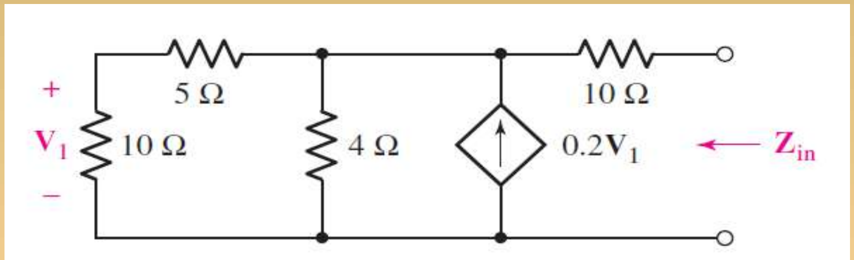
Find (a) **z**; (b) **t** for two identical networks in cascade;

Problem - 12



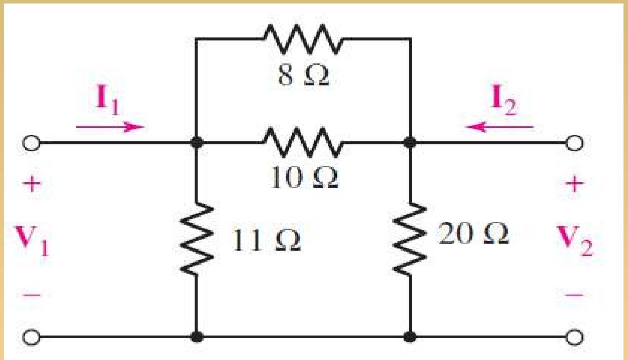
Set ω = 100π rad/s in the one-port. (a) Calculate Δ_Y and the input admittance at ω, $Y_{in}(\omega)$. (b) A sinusoidal current source having magnitude 100 A, frequency 100π rad/s, and 0° phase is connected to the network. Calculate the voltage across the current source (express answer as a phasor).

Problem - 13



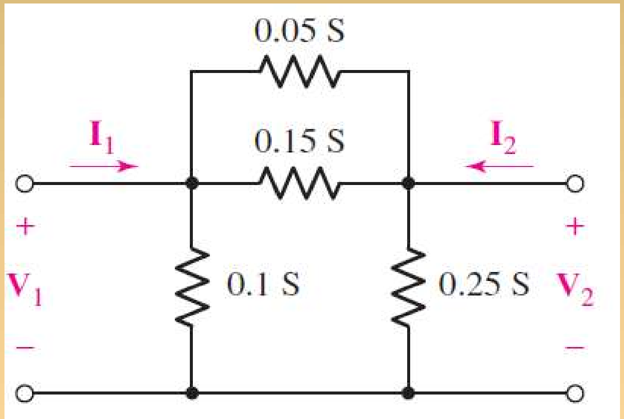
With reference to the one-port, which contains a dependent current source controlled by a resistor voltage, (a) calculate Δ_Z; (b) compute Z_{in}.

Problem - 14



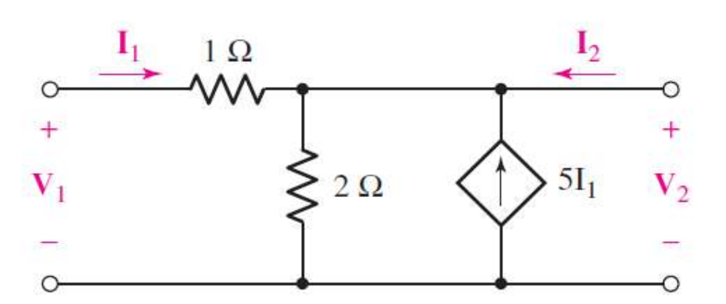
(a) Determine the short-circuit admittance parameters which completely describe the two-port network. (b) If V_1 = 3 V and V_2 = –2 V, use your answer in part (a) to compute I_1 and I_2.

Problem - 15



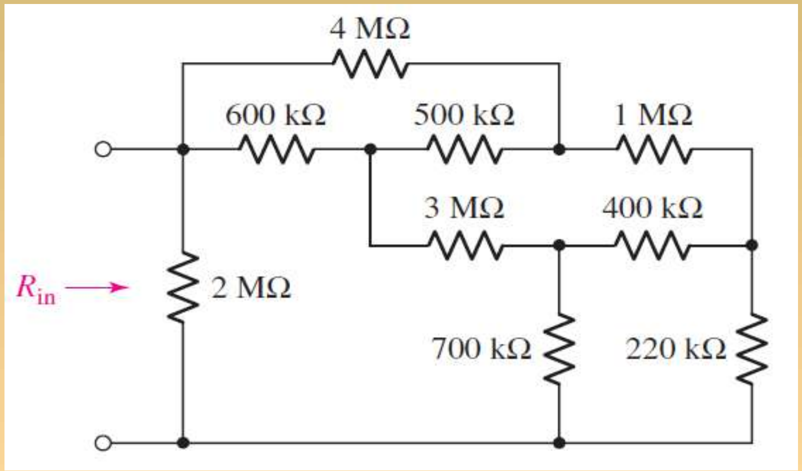
(a) Determine the **y** parameters for the two-port. (b) Define the bottom node as the reference node, and apply nodal analysis to obtain expressions for I_1 and I_2 in terms of V_1 and V_2. Use these expressions to write down the admittance matrix. (c) If $V_1 = 2V_2 = 10$ V, calculate the power dissipated in the 100 mS conductance.

Problem - 16



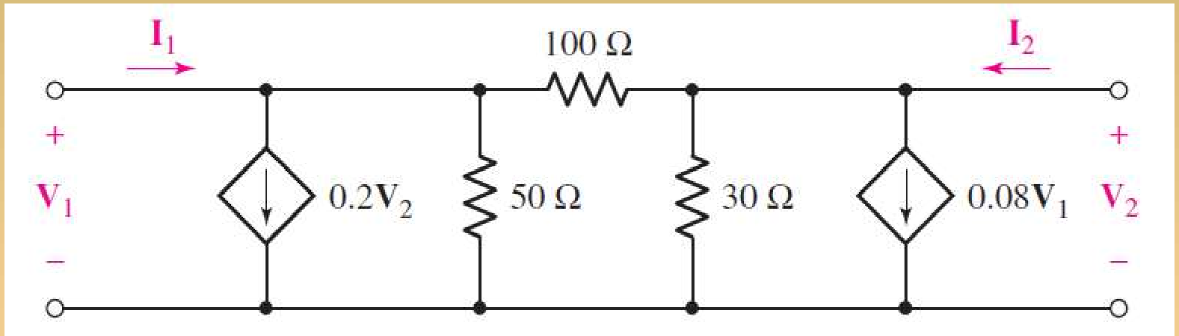
Determine the admittance parameters which describe the two-port.

Problem - 17



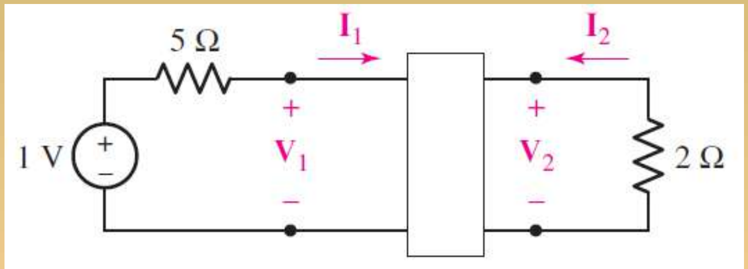
Employ Δ-Y conversion techniques as appropriate to determine the input resistance R_{in} of the one-port.

Problem - 18



Obtain both the impedance and admittance parameters for the two-port network.

Problem - 19

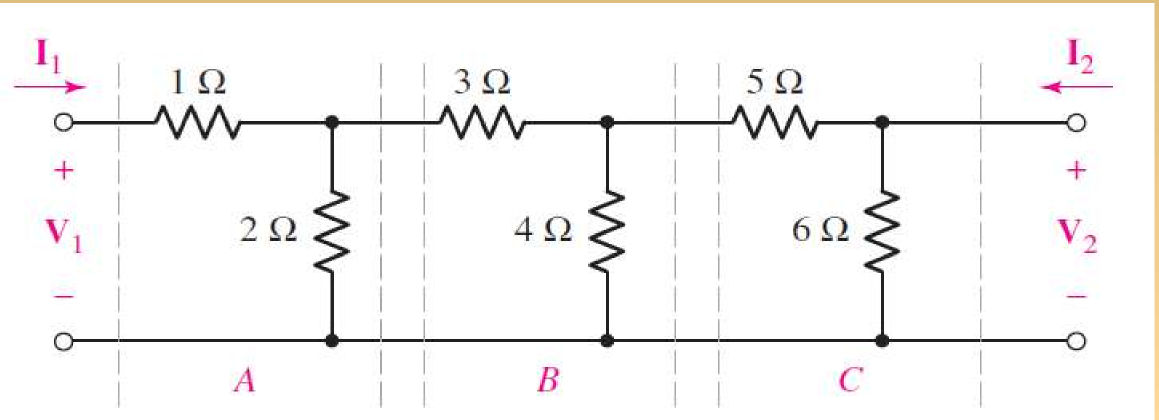


The two-port which plays a central role in the circuit can be characterized by hybrid parameters

$$\mathbf{h} = \begin{bmatrix} 1\ \Omega & -1 \\ 2 & 0.5\ \text{S} \end{bmatrix}$$

Determine I_1, I_2, V_1, and V_2.

Problem - 20



The two-port can be viewed as three separate cascaded two-ports A, B, and C. (a) Compute **t** for each network. (b) Obtain **t** for the cascaded network. (c) Verify your answer by naming the two middle nodes V_x and V_y, respectively, writing nodal equations, obtaining the admittance parameters from your nodal equations, and converting to **t** parameters.