### Important Remarks

- Homework is due on April 10 at the beginning of class.

1. Problem 8.24
2. Problem 8.28
3. Problem 8.36

nential form:

(a) $3e^{j70°}$ (e) $6e^{j90°}$
(b) $2e^{j120°}$ (f) $e^{-j90°}$
(c) $5e^{-j60°}$ (g) $2e^{j180°}$
(d) $4e^{-j150°}$ (h) $2e^{-j180°}$

**8.13** Find the rectangular form of the sum $\mathbf{A}_1 + \mathbf{A}_2$ given that
(a) $\mathbf{A}_1 = 3e^{j30°}$; $\mathbf{A}_2 = 4e^{j60°}$
(b) $\mathbf{A}_1 = 3e^{j30°}$; $\mathbf{A}_2 = 4e^{-j30°}$
(c) $\mathbf{A}_1 = 5e^{-j60°}$; $\mathbf{A}_2 = 2e^{j120°}$
(d) $\mathbf{A}_1 = 4e^{j45°}$; $\mathbf{A}_2 = 2e^{-j90°}$

**8.14** Express the following sums as a single sinusoid of the form $A\cos(\omega t + \theta)$:
(a) $3\cos(\omega t + 30°) + 4\cos(\omega t + 60°)$
(b) $3\cos(\omega t + 30°) + 4\cos(\omega t - 60°)$
(c) $5\cos(\omega t - 60°) + 2\cos(\omega t + 120°)$
(d) $4\cos(\omega t + 45°) + 2\sin\omega t$

**8.15** For the complex numbers given in Problem 8.13, find the rectangular form of the product $\mathbf{A}_1\mathbf{A}_2$.

**8.16** Verify the following identities:
(a) $Me^{j90°} = jM$
(b) $Me^{-j90°} = -jM$
(c) $Me^{j180°} = -M$
(d) $Me^{-j180°} = -M$
(e) $Me^{j0°} = M$
(f) $-Me^{j\theta} = Me^{j(\theta \pm 180°)}$

**8.17** Express the following as a single complex number in exponential form:
(a) $\dfrac{-j6}{1+j}$ (d) $\dfrac{85}{-1-j4}$
(b) $\dfrac{-8}{2+j3}$ (e) $\dfrac{200(1-j)}{4+j3}$
(c) $\dfrac{j3}{-2+j}$ (f) $\dfrac{20(1+j)}{4+j3}e^{-j30°}$
(g) $37.1e^{j14°} + 20.6e^{-j166°}$
(h) $16.5e^{j14°} + 4.12e^{-j76°}$

**8.18** Express each part of Problem 8.17 as a single complex number in rectangular form.

**8.19** Express each of the following as a single complex number:
(a) $2 + 2e^{j120°} + 2e^{-j120°}$
(b) $2e^{j60°} + 2e^{j180°} + 2e^{-j60°}$
(c) $2e^{j45°} + 2e^{j165°} + 2e^{-j75°}$

**8.20** Repeat Problem 8.1 using frequency-domain analysis. Draw the corresponding phasor diagram.

**8.21** Repeat Problem 8.2 using frequency-domain analysis. Draw the corresponding phasor diagram.

**8.22** Repeat Problem 8.3 using frequency-domain analysis. Draw the corresponding phasor diagram.

**8.23** Repeat Problem 8.4 using frequency-domain analysis. Draw the corresponding phasor diagram.

**8.24** Repeat Problem 8.5 using frequency-domain analysis. Draw the corresponding phasor diagram.

**8.25** Repeat Problem 8.6 using frequency-domain analysis. Draw the corresponding phasor diagram.

**8.26** For the series *RLC* circuit given in Fig. 8.5 (p. 352), suppose that $R = 4\ \Omega$, $L = 2$ H, and $v_s(t) = A\cos(3t + \theta)$ V. Determine by how much $v_C(t)$ either leads or lags $v_s(t)$ when $C$ is (a) $\frac{1}{8}$ F, (b) $\frac{1}{18}$ F, and (c) $\frac{1}{32}$ F.

**8.27** For the circuit shown in Fig. P8.27, (a) use mesh analysis to find $v_o(t)$, and

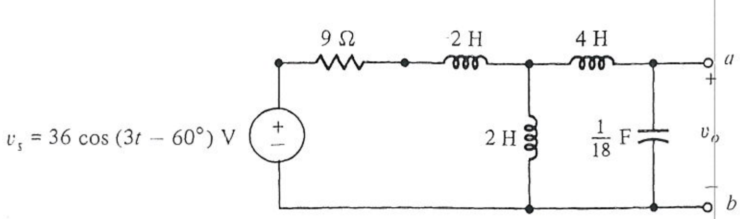


Fig. P8.27

## PROBLEMS FOR CHAPTER 8

**8.1** For the circuit shown in Fig. P8.1, suppose that $v_s(t) = 12 \cos 2t + 5 \sin 2t$ V. Find $i(t)$ and $v_o(t)$ using time-domain analysis, and determine by how much $v_o(t)$ either leads or lags $v_s(t)$.

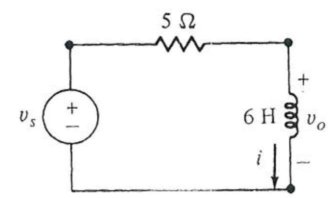


Fig. P8.1

**8.2** For the circuit shown in Fig. P8.2, suppose that $i_s(t) = 8 \sin \sqrt{3}t$ A. Find $v_o(t)$ using time-domain analysis, and determine by how much $v_o(t)$ either leads or lags $v_s(t)$.

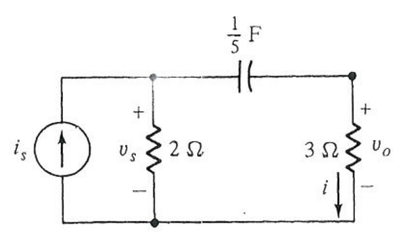


Fig. P8.2

**8.3** For the circuit given in Fig. P8.1, place an additional 5-Ω resistor in parallel with the inductor and repeat Problem 8.1.

**8.4** For the simple series $RC$ circuit given in Fig. 8.4(a) (p. 350), place an additional 1-Ω resistor in parallel with the capacitor. Find $v_o(t)$ and $i(t)$ using time-domain analysis for the resulting circuit, and determine by how much $v_o(t)$ either leads or lags $v_s(t)$.

**8.5** For the series $RLC$ circuit given in Fig. 8.5 (p. 352) suppose that $R = \frac{5}{4}$ Ω, $L = \frac{1}{4}$ H, $C = 1$ F, and $v_s(t) = 4 \cos 2t$ V. Find $v_C(t)$ using time-domain analysis, and determine by how much $v_C(t)$ either leads or lags $v_s(t)$.

**8.6** For the $RLC$ circuit shown in Fig. P8.6, suppose that $v_s(t) = 3 \cos t$ V. Find $v_C(t)$ using time-domain analysis, and determine by how much $v_C(t)$ either leads or lags $v_s(t)$.

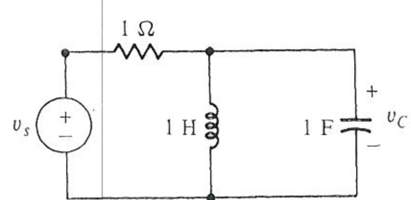


Fig. P8.6

**8.7** For the $RC$ circuit given in Fig. 8.4(a) (p. 350), find the zero-state response $v_C(t)$ for the case that the input voltage is $v_s(t) = 6 \sin 2t\, u(t)$ V. (*Note*: The zero-state response includes both the forced and the natural responses.)

**8.8** For the series $RLC$ circuit given in Fig. 8.5 (p. 352), suppose that $R = \frac{5}{4}$ Ω, $L = \frac{1}{4}$ H, and $C = 1$ F. Find the zero-state response $v_C(t)$ for the case that the input voltage is $v_s(t) = 4 \cos 2t\, u(t)$ V.

**8.9** For the circuit given in Fig. P8.6, find the zero-state response $v_C(t)$ for the case that the input voltage is $v_s(t) = 3 \cos t\, u(t)$ V.

**8.10** Repeat Problem 8.9 for the case that the value of the resistor is changed to 0.5 Ω.

**8.11** Find the exponential form of the following complex numbers given in rectangular form:

(a) $4 + j7$ (e) $4$
(b) $3 - j5$ (f) $-5$
(c) $-2 + j3$ (g) $j7$
(d) $-1 - j6$ (h) $-j2$

**8.12** Find the rectangular form of the following complex numbers given in expo-

DRILL EXERCISE 8.1

Find $i(t)$ and $v(t)$ for the circuit shown in Fig. DE8.1.

Answer: $2 \cos 2t$ A; $-8 \sin 2t$ V

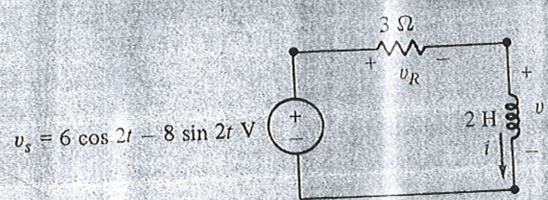


Fig. DE8.1

Having analyzed a first-order sinusoidal circuit, let us now look at an example of a second-order sinusoidal circuit.

EXAMPLE 8.2

For the series $RLC$ shown in Fig. 8.5, we have already seen [Equation (6.26) on p. 295] that

$$\frac{d^2 v_C}{dt^2} + \frac{R}{L}\frac{dv_C}{dt} + \frac{1}{LC} v_C = \frac{v_s}{LC}$$

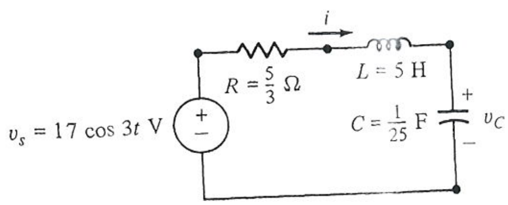


Fig. 8.5 Series $RLC$ sinusoidal circuit.

Thus,

$$\frac{d^2 v_C}{dt^2} + \frac{1}{3}\frac{dv_C}{dt} + 5v_C = 85 \cos 3t$$

and the forced response has the form

$$v_C(t) = A_1 \cos 3t + A_2 \sin 3t$$

Substituting this into the differential equation and collecting terms, we get

$$(-4A_1 + A_2)\cos 3t + (-A_1 - 4A_2)\sin 3t = 85 \cos 3t$$

Equating coefficients yields the pair of simultaneous equations

$$-4A_1 + A_2 = 85 \qquad \text{and} \qquad -A_1 - 4A_2 = 0$$

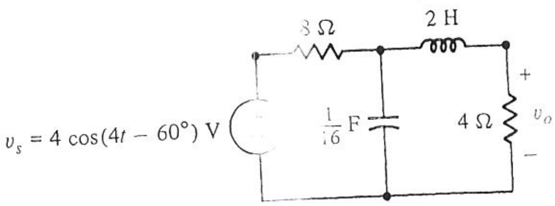


Fig. P8.28

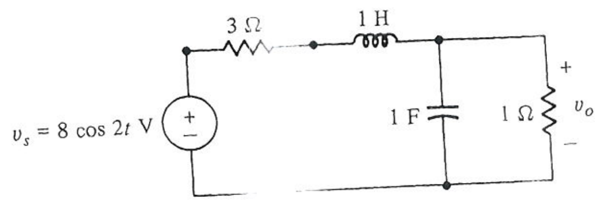


Fig. P8.29

(b) find the impedance seen by the voltage source.

**8.28** For the circuit shown in Fig. P8.28, (a) use nodal analysis to find $v_o(t)$, and (b) find the impedance seen by the voltage source.

**8.29** For the circuit shown in Fig. P8.29, (a) use nodal analysis to find $v_o(t)$, and (b) find the impedance seen by the voltage source.

**8.30** For the circuit given in Fig. P8.29, change the value of the inductor to $\frac{1}{5}$ H, and repeat Problem 8.29.

**8.31** For the *RLC* connection shown in Fig. P8.31, find the impedance **Z** when (a) $\omega = 1$ rad/s, (b) $\omega = 4$ rad/s, and (c) $\omega = 8$ rad/s.

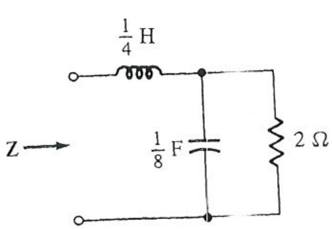


Fig. P8.31

**8.32** For the *RLC* connection shown in Fig. P8.32, find the admittance **Y** when

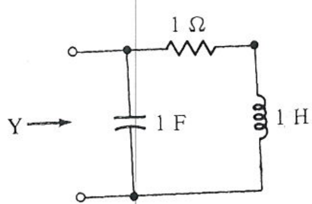


Fig. P8.32

(a) $\omega = 1$ rad/s, (b) $\omega = \frac{1}{2}$ rad/s, and (c) $\omega = \frac{1}{4}$ rad/s.

**8.33** Consider the circuit given in Fig. P8.3_. (a) Find $v_o(t)$ by using voltage division. (b) Place an additional 5-Ω resistor in parallel with the inductor, and find $v_o(t)$ for the resulting circuit by using voltage division.

**8.34** For the circuit given in Fig. P8.2_, find $i(t)$ by using current division.

**8.35** For the circuit given in Fig. P8.2_, find the Thévenin-equivalent circuit with respect to terminals $a$ and $b$.

**8.36** For the circuit given in Fig. P8.28, find $v_o(t)$ by first replacing the portion of the circuit to the left of the 4-Ω resistor with its Thévenin equivalent.

**8.37** For the circuit given in Fig. P8.29, find $v_o(t)$ by first replacing the portion of the circuit to the left of the 1-Ω resistor with its Norton equivalent.

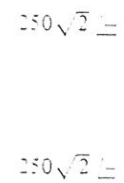


Fig P8.3

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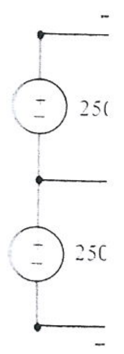


Fig. P8.4

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Fig. P8.4