ECE 201, Section 3
Lecture 36

Prof. Peter Bermel
November 26, 2012
Exam #3

• Out of 158 exams taken: $\mu=53\%$, $\sigma=17\%$
• Much more challenging than last time
Exam Z-Scores

- Z-scores calculated from your score $s$ by:
  $Z = \frac{s - \mu}{\sigma}$

- General scale:

<table>
<thead>
<tr>
<th>Z-score range</th>
<th>Approximate Letter Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z&gt;1$</td>
<td>A/A-</td>
</tr>
<tr>
<td>$Z&gt;0$</td>
<td>B+/B/B-</td>
</tr>
<tr>
<td>$Z&gt;-0.6$</td>
<td>C+/C/C-</td>
</tr>
<tr>
<td>$Z&gt;-1$</td>
<td>D</td>
</tr>
<tr>
<td>$Z&lt;-1$</td>
<td>F</td>
</tr>
</tbody>
</table>
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# of students

![Bar chart showing the number of students in different Z-score ranges.]

- Z<-1
- Z≥-1
- Z>-0.6
- Z>0
- Z>1

Z-score range
Exam #3

% correct for each question

![Bar chart showing the percentage of correct answers for each question number from 7 to 2]
Solutions for Exam #3

• Posted original exam, answer key, and full solutions under “Fall 2012 Exams” folder
• Will review the following problems today: 3, 4, 6, 7, 8, 9, 10, 13
3. For the circuit below, what is the output voltage $V_{out}(t)$ (in V), for $t \geq 0$?

![Circuit Diagram]

Answers:

(1) $2e^{-t}$
(2) $2e^{-10t}$
(3) $4e^{-10t}$
(4) $4(1-e^{-t})$
(5) $8e^{-t}$
(6) $8(1-e^{-t})$
(7) $16e^{-10t}$
(8) None of the above
4. Given that $R=2 \, \Omega$, $C=50 \, \text{mF}$, and input voltage $v_s(t)=20u(t)\sin(40t)$ V for the circuit below, what is the output voltage $v_o(t)$ (in V) for $t \geq 0$?

Answers:
(1) $\sin(40t)$
(2) $1-\cos(40t)$
(3) $5 \sin(40t)$
(4) $5[\cos(40t)-1]$
(5) $10 \sin(40t)$
(6) $10[1-\cos(40t)]$
(7) $20 \sin(40t)$
(8) None of the above
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6. For the circuit below, what is the inductor current \( I_L(t) \) (in A) for \( t \geq 0 \)?

![Circuit Diagram]

Answers:

1. \(-3e^{-40t} \cos(50t)\)
2. \(6e^{-40t} \cos(30t)\)
3. \((-3+6t) e^{-50t}\)
4. \(-3 + 12e^{20t} - 12e^{-80t}\)
5. \(3 - 6e^{-40t} \cos(50t)\)
6. \(6 + (18t-9)e^{-50t}\)
7. \(6 - 12e^{-20t} + 3e^{-30t}\)
8. None of the above
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7. For the circuit below, find the inductor current $I_L(t)$ (in A) for $t \geq 0$:

\[ \text{12u}(-t) \]

Answers:

1. $0.06e^{-400t}$
2. $0.12 \cos(400t)$
3. $(0.12+48t)e^{-400t}$
4. $0.12e^{-400t}$
5. $0.18e^{-400t} - 0.06e^{-1200t}$
6. $0.24 \cos(400t)$
7. $0.24e^{-400t}$
8. None of the above
8. For the circuit below, what is $V_c(t)$ (in V) for $t \geq 0$?

![Circuit Diagram]

Answers:

1. $12 \cos(30t)$
2. $12 \cos(40t)$
3. $12e^{-40t} \cos(30t-53.13^\circ)$
4. $20e^{-30t} \cos(40t+36.87^\circ)$
5. $20e^{-40t} \cos(30t-53.13^\circ)$
6. $20e^{-30t} \cos(50t+36.87^\circ)$
7. $(12+24t) e^{-50t}$
8. None of the above
9. For the circuit below, what is the resistor voltage $V_R(t)$ (in V) in the sinusoidal steady state?

\[ V_{in} = 2 \sin(100t) \]

Answers:
(1) $0.5 \cos(100t+45^\circ)$
(2) $0.5 \cos(100t-135^\circ)$
(3) $2^{1/2} \cos(100t-135^\circ)$
(4) $\cos(100t-90^\circ)$
(5) $\cos(100t)$
(6) $2^{1/2} \cos(100t+45^\circ)$
(7) $2^{1/2} \cos(100t-135^\circ)$
(8) None of the above
10. What is the output voltage $V_{out}$ (in V) for the circuit below, in the sinusoidal steady state?

$I_1 = 1.2 \cos(200t)$

$V_{out}$

$25 \Omega$

$0.4 \text{ mF}$

$0.1 \text{ H}$

$I_2 = 1.6 \sin(200t)$

Answers:

(1) 20 $\cos(200t)$

(2) 20 $\sin(200t)$

(3) 40 $\cos(200t)$

(4) 40 $\sin(200t)$

(5) 56 $\cos(200t)$

(6) 70 $\cos(200t)$

(7) 70 $\sin(200t)$

(8) None of the above
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13. For the circuit below in the sinusoidal steady state, what is $V_{\text{out}}$ (in V)?

\[ V_{\text{in}} = 2 \cos(4000t) \]

Answers:

1. $50 \sin(4000t)$
2. $50 \cos(4000t - 45^\circ)$
3. $50 \cos(4000t)$
4. $100 \sin(4000t)$
5. $100 \cos(4000t - 45^\circ)$
6. $100 \cos(4000t)$
7. $100 \cos(4000t + 45^\circ)$
8. None of the above
Average Power for SSS

Over half-integer periods, only the first term contributes, so that

\[ P_{ave} = \frac{1}{2} I_o V_o \cos \phi \]
Effective Values

• We can generally define effective values for periodic signals, $f(t + T) = f(t)$, such that:

$$F_{eff} = \sqrt{\frac{1}{T} \int_{t_0}^{t_0+T} dt \ [f(t)]^2}$$

• Also known as root-mean-square (rms) value

• For AC signals, $F_{eff} = \frac{f_0}{\sqrt{2}}$
Power from Effective Values

• Revisiting our calculation from last time:

\[ P_{ave} = \frac{1}{2} I_o V_o \cos \phi \]

Rewriting in our new notation:

\[ P_{ave} = I_{eff} V_{eff} \cos \phi \]

In electrical engineering, drop the effective subscripts and write:

\[ P_{ave} = IV \cos \phi \]
Complex Power

• Complex power is defined as:

\[ S = I^*V \]

• For AC signals:

\[ S = I_0 e^{-j\omega t} V_0 e^{j(\omega t + \phi)} \]
\[ S = I_0 V_0 e^{j\phi} = I_0 V_0 (\cos \phi + j \sin \phi) \]

• Key definitions:
  - Re S – average power
  - Im S – reactive power
  - |S| – complex power
Complex Power Example

• What is the current and complex power dissipated by this circuit?

\[ V_{\text{in}} = 6 \cos(\omega t) \]
Complex Power: Solution

\[ I_{in} = 3 \cos(\omega t) \]

- The impedance is given by:

\[ Z = \left[ \frac{3}{2} + j\omega \cdot 5 \cdot 10^{-4} + \frac{1}{j\omega \cdot 2 \cdot 10^{-3}} \right]^{-1} \]

- The voltage drop is thus given by:

\[ V = IZ = \frac{3e^{j\omega t}}{\frac{3}{2} + j \cdot (\omega/2000 - 500/\omega)} \]

\[ V = 2e^{j\left[\omega t - \tan^{-1}\left(\frac{\omega}{3000} - \frac{1000}{3\omega}\right)\right]} \left[1 + \left(\frac{\omega}{3000} - \frac{1000}{3\omega}\right)^2\right]^{1/2} \]
Complex Power: Solution

- Applying the current division rule:

\[
I_L = \frac{Y_L}{Y} I_{tot}
\]

\[
I_L = \frac{(500/j\omega)3e^{j\omega t}}{\frac{3}{2} + j \cdot (\omega/2000 - 500/\omega)} = \frac{1000e^{j\omega t}}{j\omega + \frac{1000}{3} - \frac{\omega^2}{3000}}
\]

\[
I_L = \frac{1000e^{j[\omega t - \tan^{-1}(\omega/(333 - \omega^2/3000))]} }{\left[\omega^2 + \left(\frac{1000}{3} - \frac{\omega^2}{3000}\right)^2\right]^{1/2}}
\]
Solution

Inductor Current Amplitude (A)

Frequency (rad/s)
Complex Power: Solution

• From our earlier definitions:

\[ S = I^*V \]

• Substitution yields:

\[ S = \frac{1000e^{-j[\omega t - \tan^{-1}(\omega/(333-\omega^2/3000))]}}{\left[ \omega^2 + \left( \frac{1000}{3} - \frac{\omega^2}{3000} \right)^2 \right]^{1/2}} \cdot 6e^{j\omega t} \]

\[ S = 6000 \cdot \frac{333 - \frac{\omega^2}{3000} + j\omega}{\left[ \omega^2 + \left( \frac{1000}{3} - \frac{\omega^2}{3000} \right)^2 \right]^{3/2}} \]
Solution

Average Power (mW)

Frequency (rad/s)
Homework

- HW #35 and extra credit assignment due today by 4:30 pm in EE 325B

- HW #36 due Wed.: DeCarlo & Lin, Chapter 11:
  - Problem 1
  - Problem 3