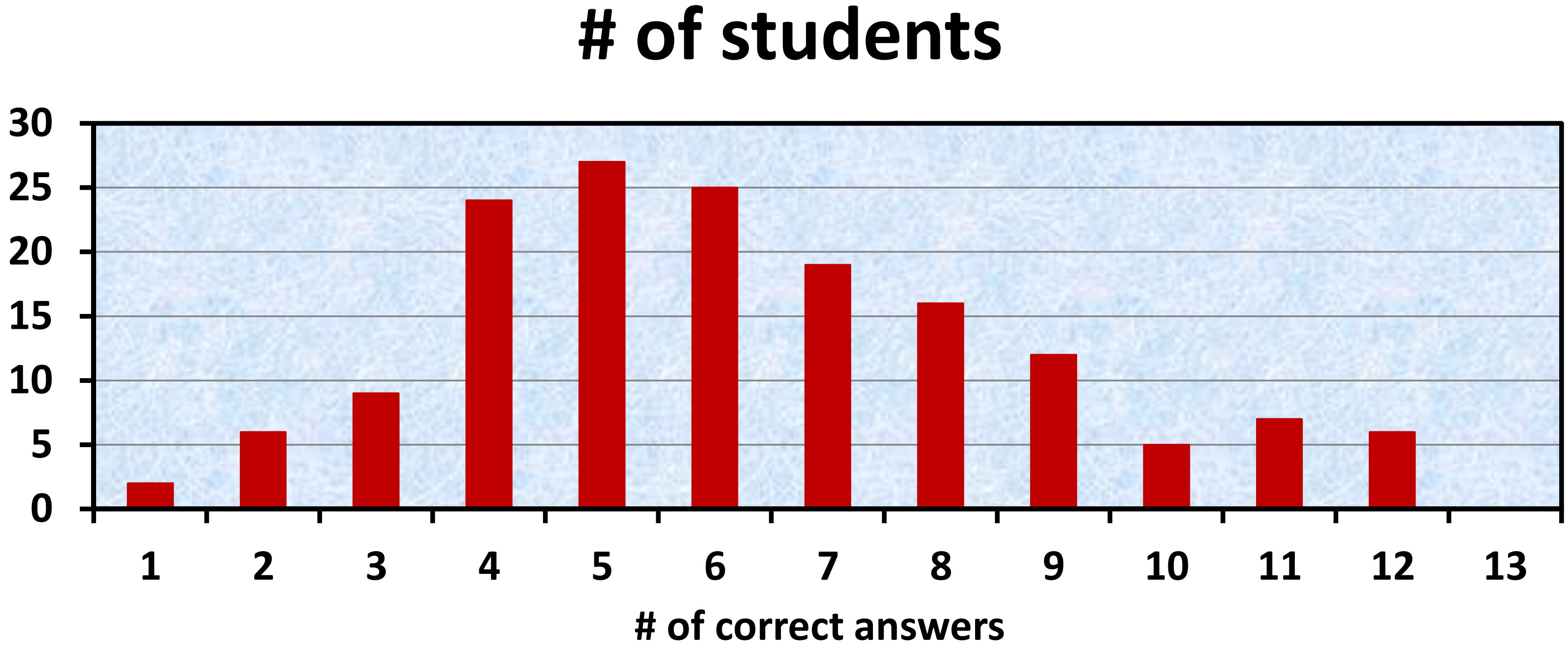
ECE 201, Section 3
Lecture 36

Prof. Peter Bermel

November 26, 2012

Exam #3

- Out of 158 exams taken: μ=53%, σ=17%
- Much more challenging than last time



Exam Z-Scores

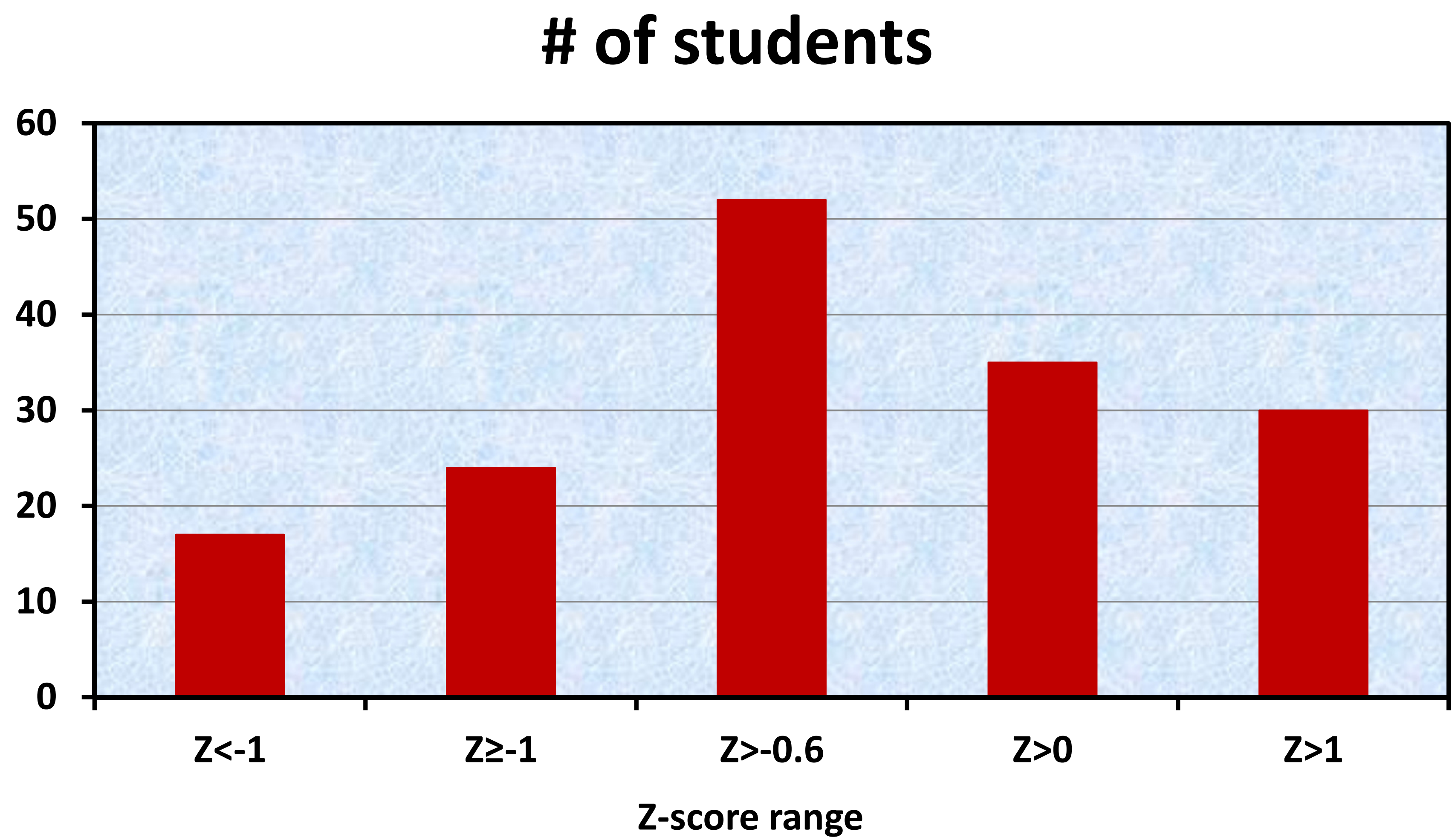
- Z-scores calculated from your score *s* by:

$$Z = \frac{s - \mu}{\sigma}$$

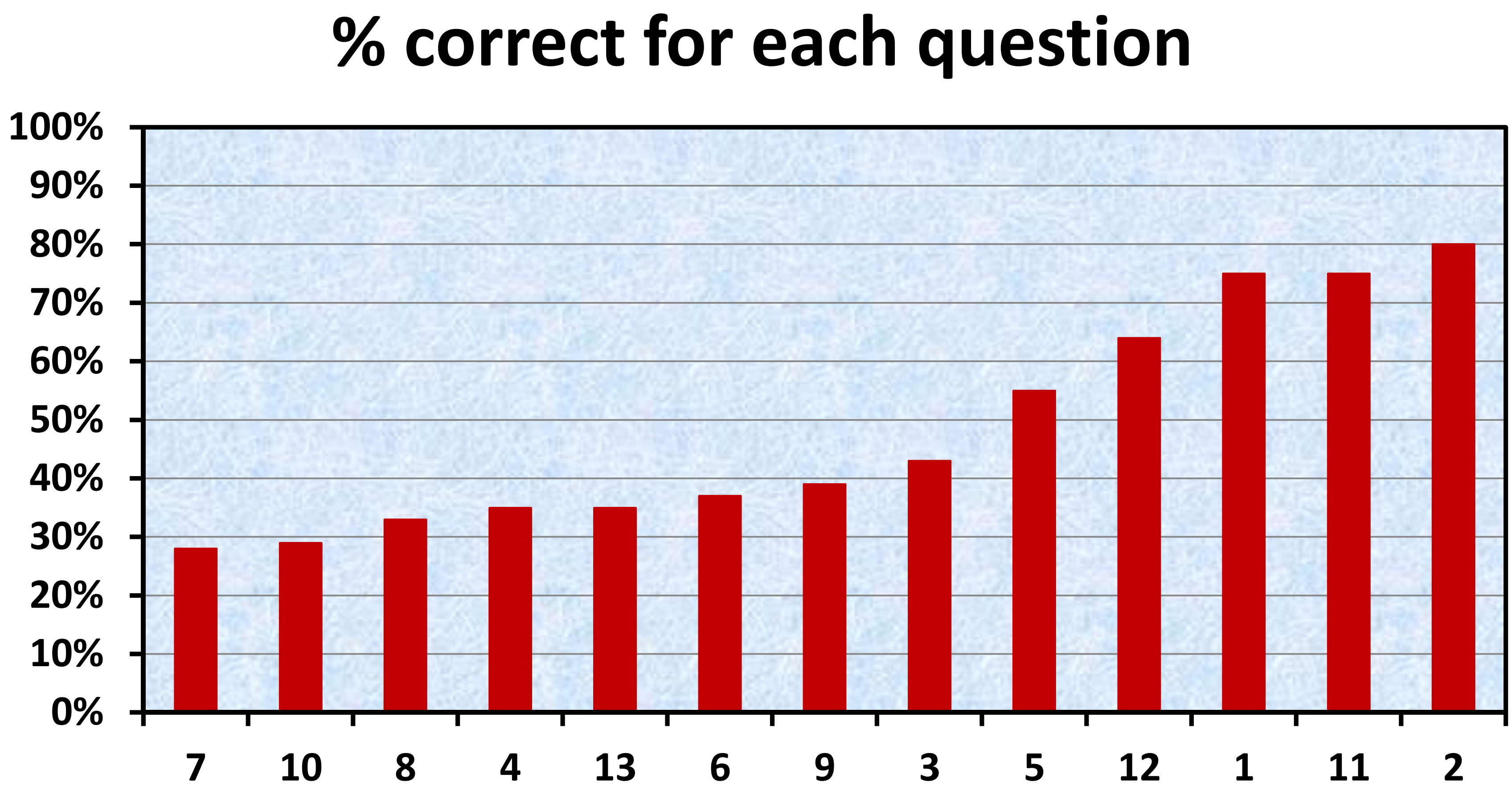
- General scale:

Z-score range	Approximate Letter Grade
Z>1	A/A-
Z>0	B+/B/B-
Z>-0.6	C+/C/C-
Z>-1	D
Z<-1	F

Exam #3



Exam #3

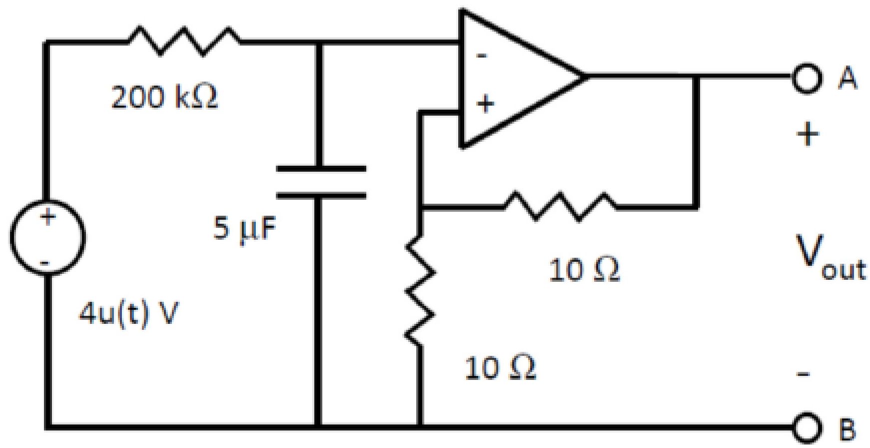

% correct for each question
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
7
10
8
4
13
6
9
3
5
12
1
11
2

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

Exam #3

3. For the circuit below, what is the output voltage $V_{out}(t)$ (in V), for $t \geq 0$?

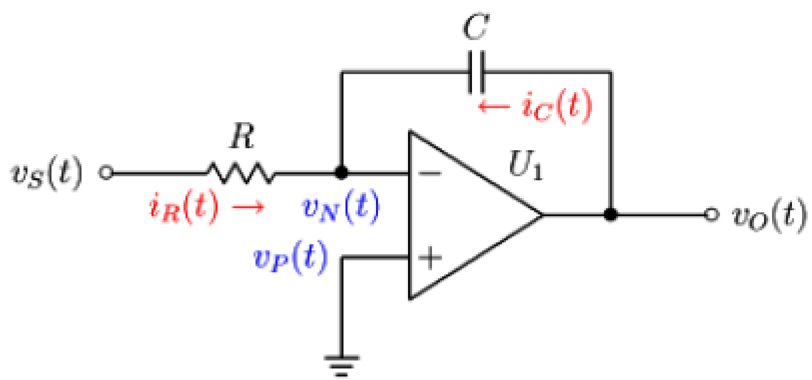


Answers:

(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

Exam #3

4. Given that R=2 Ω, C=50 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≥0?

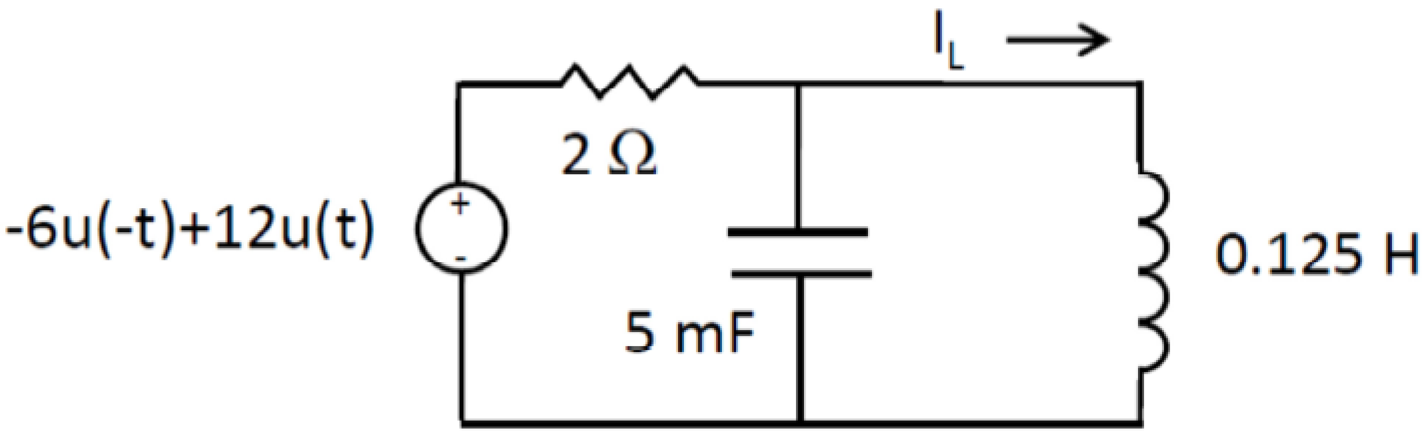


Answers:

(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

Exam #3

6. For the circuit below, what is the inductor current $I_L(t)$ (in A) for $t \geq 0$?

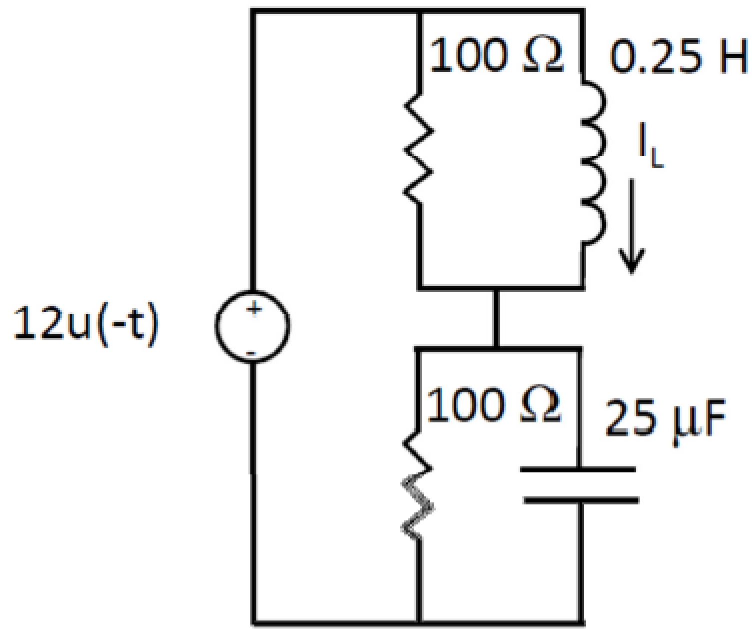


Answers:

(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) $6 - 12e^{-20t} + 3e^{-80t}$
(8) None of the above

Exam #3

7. For the circuit below, find the inductor current $I_L(t)$ (in A) for $t \geq 0$:

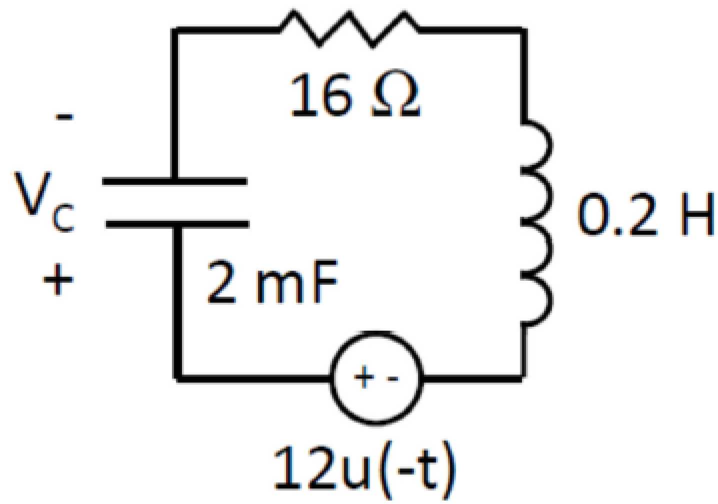


Answers:

(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) $0.24\ e^{-400t}$
(8) None of the above

Exam #3

8. For the circuit below, what is $V_c(t)$ (in V) for $t \geq 0$?

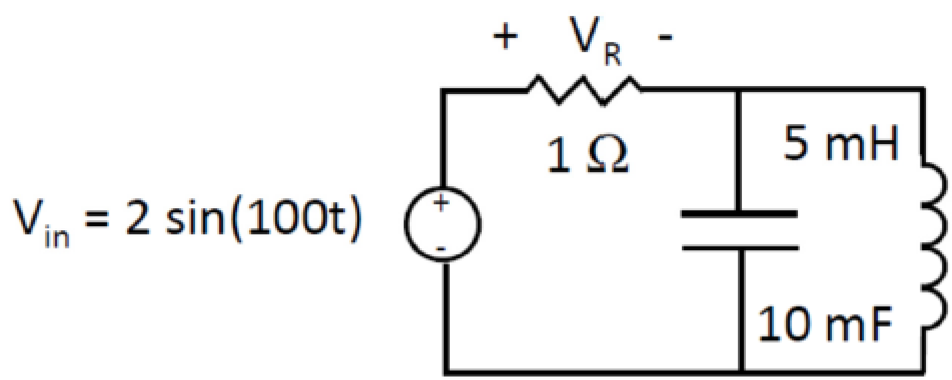


Answers:

(1) 12 cos(30t)
(2) 12 cos(40t)
(3) $12e^{-40t}\cos(30t-53.13°)$
(4) $20e^{-30t}\cos(40t+36.87°)$
(5) $20e^{-40t}\cos(30t-53.13°)$
(6) $20e^{-30t}\cos(50t+36.87°)$
(7) $(12+24t)\,e^{-50t}$
(8) None of the above

Exam #3

9. For the circuit below, what is the resistor voltage $V_R(t)$ (in V) in the sinusoidal steady state?

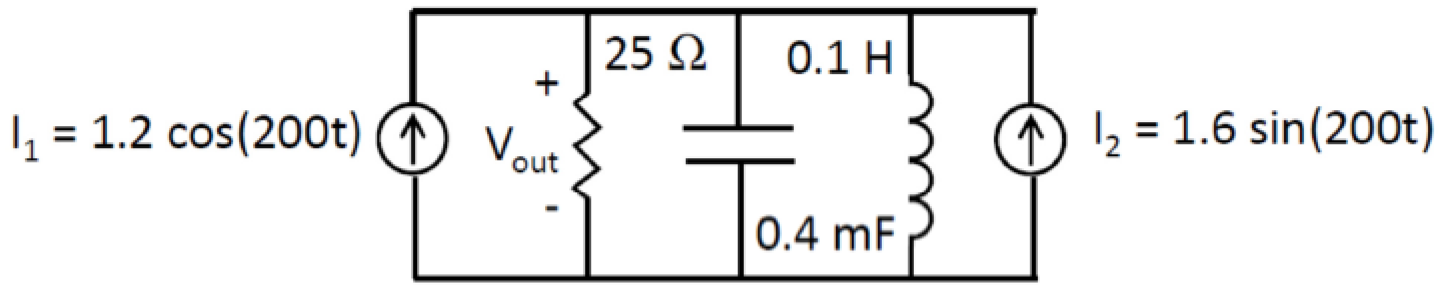


Answers:

(1) $0.5\cos(100t+45°)$
(2) $0.5\cos(100t-135°)$
(3) $2^{-1/2}\cos(100t-135°)$
(4) $\cos(100t-90°)$
(5) $\cos(100t)$
(6) $2^{1/2}\cos(100t+45°)$
(7) $2^{1/2}\cos(100t-135°)$
(8) None of the above

Exam #3

10. What is the output voltage V_{out} (in V) for the circuit below, in the sinusoidal steady state?

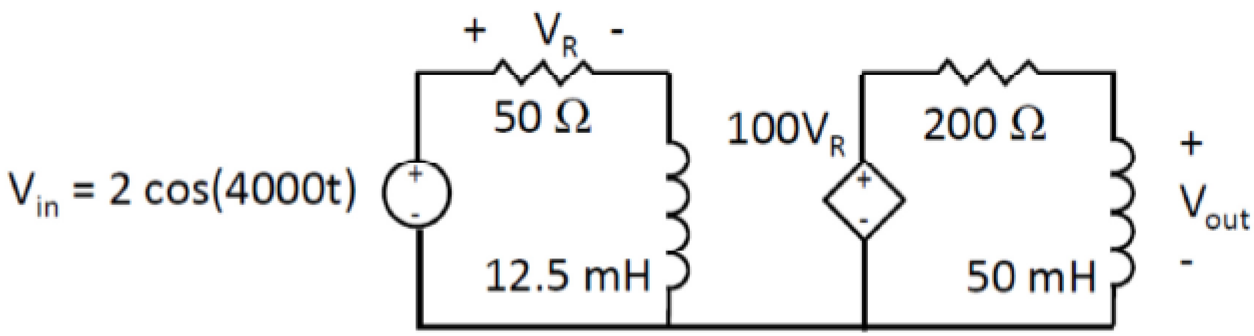


Answers:

(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

Exam #3

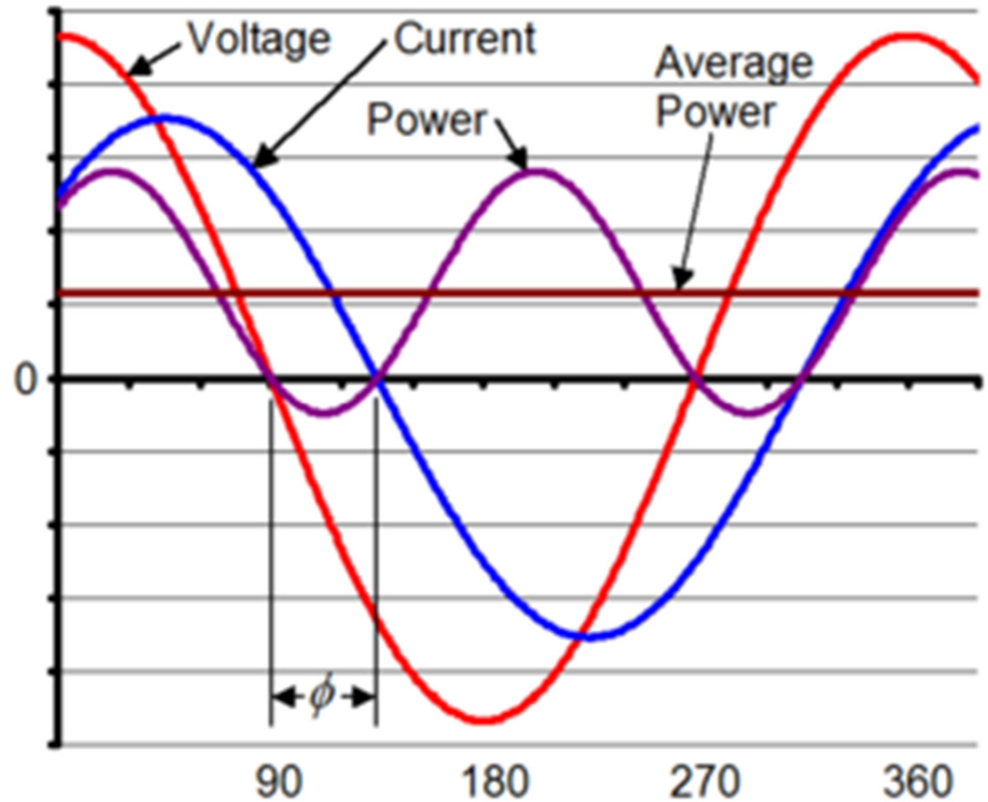
13. For the circuit below in the sinusoidal steady state, what is V_{out} (in V)?



Answers:

(1) 50 sin(4000t)
(2) 50 cos(4000t-45°)
(3) 50 cos(4000t)
(4) 100 sin(4000t)
(5) 100 cos(4000t-45°)
(6) 100 cos(4000t)
(7) 100 cos(4000t+45°)
(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:

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

- Also known as root-mean-square (rms) value
- For AC signals, $F_{eff} = \frac{f_o}{\sqrt{2}}$

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:

$$\boldsymbol{S} = \boldsymbol{I}^{*}\boldsymbol{V}$$

- For AC signals:

$$\boldsymbol{S} = I_o e^{-j\omega t} V_o e^{j(\omega t+\phi)}$$

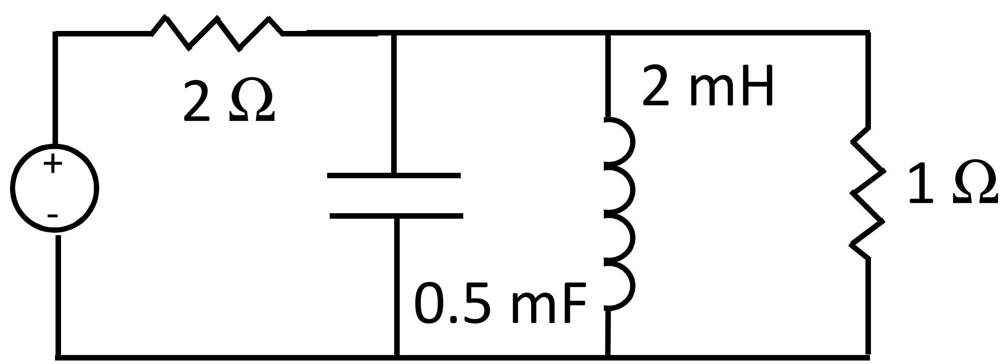
$$\boldsymbol{S} = I_o V_o e^{j\phi} = I_o V_o(\cos\phi + j\sin\phi)$$

- Key definitions:
  - Re S – average power
  - Im S – reactive power
  - |S| – complex power

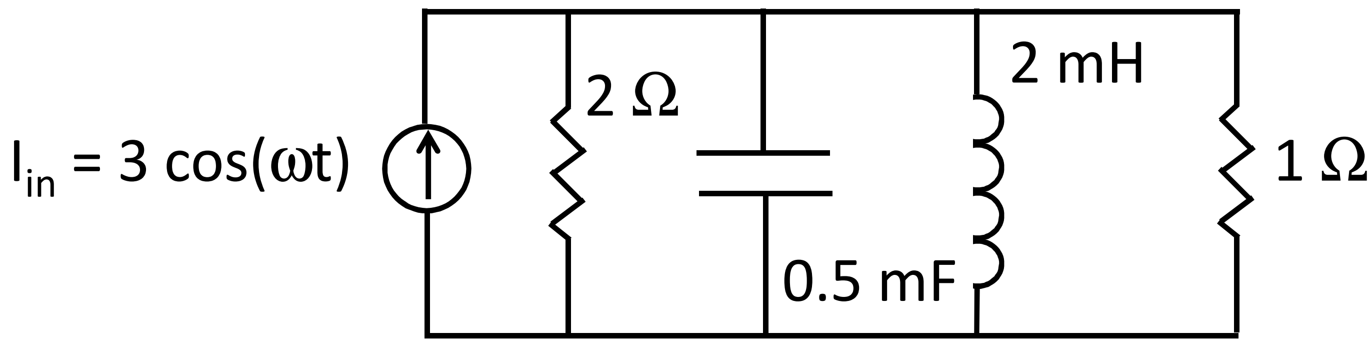
Complex Power Example

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

$V_{in} = 6\cos(\omega t)$



Complex Power: Solution



- 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:

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

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

Complex Power: Solution

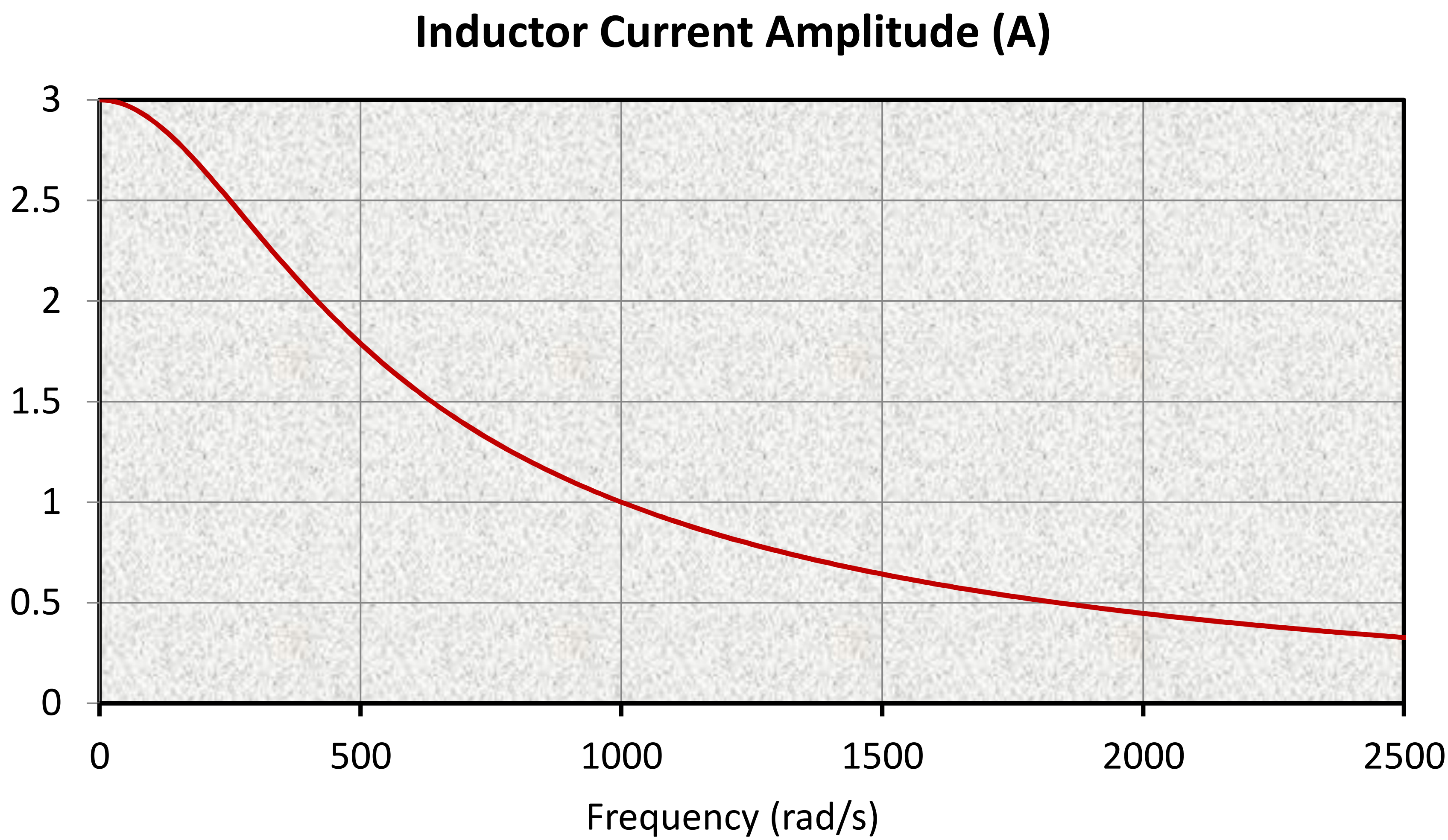
- Applying the current division rule:

$$I_L = \frac{Y_L}{Y} I_{tot}$$

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

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

Solution



Inductor Current Amplitude (A)
3
2.5
2
1.5
1
0.5
0
0
500
1000
1500
2000
2500
Frequency (rad/s)

Complex Power: Solution

- From our earlier definitions:

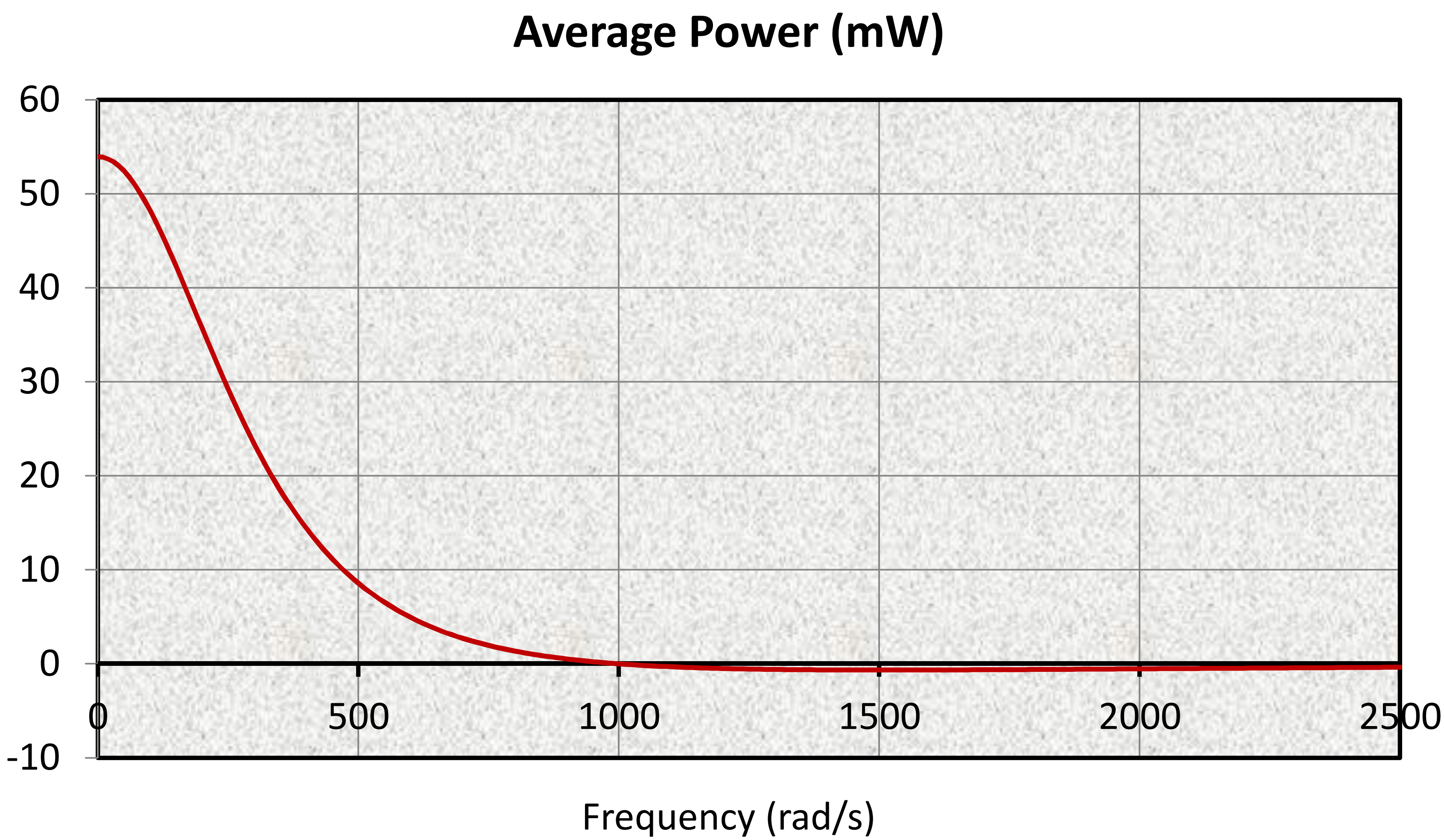
$$\boldsymbol{S} = \boldsymbol{I}^{*}\boldsymbol{V}$$

- Substitution yields:

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

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

Solution



Average Power (mW)
60
50
40
30
20
10
0
-10
0
500
1000
1500
2000
2500
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