

**BioE 1310 - Review AC Concepts**

3/20/2010

Instructions: On the Answer Sheet, enter your 2-digit ID number (with a leading 0 if needed) in the boxes of the ID section. *Fill in the corresponding numbered circles.* Answer each of the numbered questions by filling in the corresponding circles in the numbered question section. Print your name in the space at the bottom of the answer sheet. Sign here stating that you have neither given nor received help.

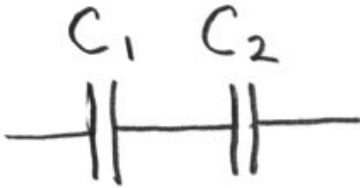
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1. A 1 F capacitor begins with no charge on it. A current of 3 A is then flows one way through the capacitor for 4 seconds. A current of 2 A then flows the other way through the same capacitor for 2 seconds. The voltage on the capacitor immediately after that is

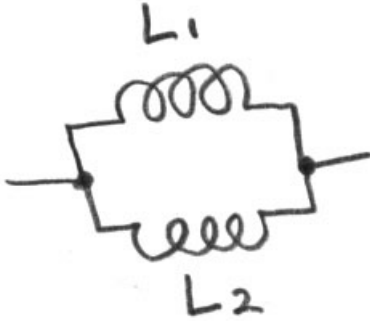
- A. 5 V
- B. 0 V
- C. 16 V
- D. 8 V
- E. not determinable from the data given.

2. What is the total capacitance of this branch if  $C_1 = 100 \mu\text{F}$ ,  $C_2 = 40 \mu\text{F}$ ?



- A. 7.14 mF
- B. 28.6  $\mu\text{F}$
- C. 60  $\mu\text{F}$
- D. 0  $\Omega$
- E. 140  $\mu\text{F}$

3. What is the total inductance of this branch if  $L_1 = 5 \mu\text{H}$ ,  $L_2 = 10 \text{ H}$ ?



- A.  $3.3 \mu\text{F}$
- B.  $2000 \mu\text{H}$
- C.  $10 \text{ H}$
- D.  $5 \mu\text{H}$
- E.  $15 \mu\text{H}$

4. The property of inductance may best be described as

- A. the magnetic field surrounding a current providing something roughly akin to ‘inertia’ to that current.
- B. electrons becoming concentrated on one plate causing electrons to leave the other plate.
- C. electrons becoming concentrated in a piece of wire due to the surrounding magnetic field.
- D. the mass of the electrons making them want to keep going in a straight line.
- E. the magnetic field around a piece of wire interacting with the magnetic field of the earth.

5. A current is increased linearly from 1 A to 6 A over 10 seconds in a 100 mH inductor. During that time, what voltage would be measured across the inductor?

- A. 50 mV
- B. 0 V
- C. 5 V
- D. cannot be determined without knowing the other components in the circuit
- E. 50 V

6. A condenser microphone is reported to have a signal-to-noise ratio of 60dB. This means that the ratio of the largest amplitude the microphone is capable of handling to the amplitude of background noise seen on the microphone’s output is

- A. 1,000
- B. 60,000
- C. 60
- D. 1,000,000
- E. 30

7. Evaluate the complex number expressed in polar notation by  $\frac{6\angle 90^\circ}{3\angle 45^\circ}$

- A.  $2\angle 235^\circ$
- B.  $3\angle 2^\circ$
- C.  $\sqrt{2}(1 + i)$
- D.  $\frac{\sqrt{2}}{2}(1 + i)$
- E. none of the other answers

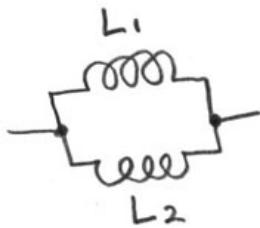
8. A current of 10 A is flowing in a 10 H inductor. What voltage would theoretically develop across the inductor if the current were stopped instantly?

- A. 0 V
- B. 100 V
- C. 1 V
- D. 50 V
- E.  $\infty$  V

9. The following are true regarding square and triangle waves *except*, (or all are true).

- A. Neither wave can be actually created because infinitely high harmonics would be required.
- B. All are true.
- C. Square waves sound “harsher” than triangle waves because higher harmonics have greater amplitudes in the square wave as compared to the triangle wave.
- D. Square waves result from differentiating triangle waves, which boosts their higher harmonics.
- E. Each wave can be mathematically represented by a Fourier series of harmonics.

10. If  $L_1 = 150\text{mH}$ ,  $L_2 = 300\text{mH}$ , the circuit below is equivalent to



- A. a single 450mH inductor.
- B. a single 100mH inductor.
- C. none of the other answers.
- D. a single 100mF capacitor.
- E. an RC filter

11. If  $L = 250\text{mH}$ ,  $C = 300\mu\text{F}$ , the circuit below has zero impedance at what frequency (in Hz)?



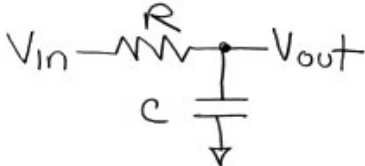
- A. 13.3 KHz
- B. 83.8 KHz
- C. 115 Hz
- D. 75 KHz
- E. 18.4 Hz

12. What is the total complex impedance (in ohms) of this branch if  $C = 0.1\mu\text{F}$ ,  $R = 10\text{K}\Omega$ ,  $f = 1000\text{Hz}$ ?



- A.  $10^4 + 10^4j$
- B.  $10^4 - 1.59 \times 10^3j$
- C.  $10^4 - 10^7j$
- D.  $10^4 + 1.59 \times 10^3j$
- E.  $10^4 - 10^4j$

13. Which of the following is (are) true about the circuit below, given that  $R = 1\text{M}\Omega$  and  $C = .01\mu\text{F}$ .



- I - The circuit is a high pass filter.
- II -  $|V_{out}| = \frac{1}{2}|V_{in}|$  at frequency  $f = 15.9\text{ Hz}$ .
- III - Since it is constructed from linear components, the circuit represents a linear system.

- A. I, II and III
- B. I and III
- C. I, and II
- D. II and III
- E. III

14. Euler's Identity  $e^{j\theta} = \cos \theta + i \sin \theta$ , can be rewritten as  $\cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2}$  and  $\sin \theta = \frac{e^{j\theta} - e^{-j\theta}}{2j}$ . Using these, which of the following is an equivalent expression for  $\cos^2 \theta$ ?

- A.  $\frac{1 - \cos 2\theta}{2}$
- B.  $\frac{1 + \sin 2\theta}{2}$
- C.  $\frac{1 + \cos 2\theta}{2}$
- D.  $\sin^2 \theta$
- E.  $\frac{1 - \cos 2\theta}{2}$

15. If  $L = 125\text{mH}$ ,  $C = 150\mu\text{F}$ , the circuit below has zero impedance at what frequency (in Hz)? (Recall that  $Z_L = j\omega L$  and  $Z_C = \frac{1}{j\omega C}$ , where frequency in Hz  $f = \omega/2\pi$ ).



- A. 36.8 Hz
- B. 150 KHz
- C. 26.6 KHz
- D. 167.6 KHz
- E. 230 Hz

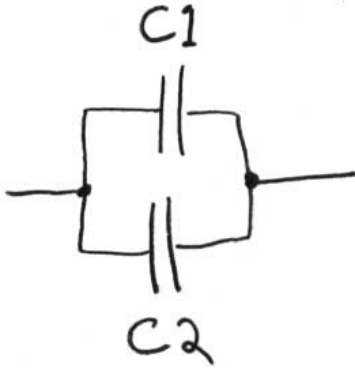
16. The inductance of a coil produces a relationship between current and voltage described by  $V = L \frac{dI}{dt}$ . All of the following are true *except*

- A. Energy is stored in the magnetic field of the coil, making it take a voltage to change the current over time.
- B. The equivalent equation for capacitance is  $I = C \frac{dV}{dt}$ , which basically says that to build up a charge on the capacitor over time takes a current.
- C. The larger the inductance  $L$ , the more rapid the change in current for a given voltage.
- D. The same relationship can also be written  $I = \frac{1}{L} \int V dt$
- E. To intentionally produce a spark, as in a spark-plug in your car, one uses a coil with a large inductance  $L$  and interrupts a large current by opening a switch.

17. The current entering one wire into a perfect capacitor

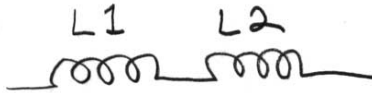
- A. can continue forever without experiencing the buildup of a voltage.
- B. experiences the buildup over time of a voltage pushing back against it proportional to the capacitance.
- C. cannot actually enter the capacitor at all, because no charge can accumulate on either of the individual plates inside the capacitor.
- D. is of much larger magnitude than the current leaving via the other wire, resulting in the buildup of voltage across the capacitor.
- E. results in charge building up on one plate of the capacitor, which pushes charge off of the other plate out the other wire.

18. What is the total capacitance of this branch if  $C_1 = 20 \mu\text{F}$ ,  $C_2 = 20 \mu\text{F}$ ?



- A.  $20 \mu\text{F}$
- B.  $5 \mu\text{F}$
- C.  $40 \mu\text{F}$
- D. Cannot be determined without knowing the frequency.
- E.  $10 \mu\text{F}$

19. What is the total inductance of this branch if  $L_1 = 5 \mu\text{H}$ ,  $L_2 = 10 \mu\text{H}$ ?



- A.  $3.3 \mu\text{F}$
- B. 10 H
- C.  $2000 \mu\text{H}$
- D.  $15 \mu\text{H}$
- E.  $5 \mu\text{H}$

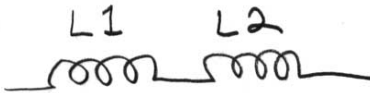
20. A current is decreased linearly from 10 A to 0 A over 0.01 seconds in a 5 H inductor. During that time, what voltage would be measured across the inductor?

- A. -20 mV
- B. cannot be determined without knowing the other components in the circuit
- C. -0.5 V
- D. -200 V
- E. -5000 V

21. The following are true about the discharge of a capacitor with capacitance  $C$  through a resistor with resistance  $R$ , *except*

- A. The discharge is governed by a first order differential equation similar to that governing radioactive decay of a certain initial amount of Carbon-14.
- B. The energy initially stored in the capacitor is released as heat by the resistor.
- C. Current will gradually decrease as the capacitor discharges.
- D. The time required to discharge to a certain percentage of the initial charge is proportional to  $RC$ .
- E. Electrons leaving the positively charged plate of the capacitor are replaced by electrons entering the negatively charged plate.

22. What is the total inductance of this branch if  $L_1 = 5$  H,  $L_2 = 10$  H?



- A.  $2000 \mu\text{H}$
- B.  $5 \mu\text{H}$
- C.  $3.3 \mu\text{F}$
- D.  $15 \mu\text{H}$
- E. 10 H

23. The following are true regarding a circuit containing a resistor and a capacitor with the following relationship between input and output voltages

$$\frac{V_{out}}{V_{in}} = \frac{1}{1+j\omega RC}$$

at frequency  $\omega$ , *except*,

- A. It lets all frequencies through equally.
- B. At  $\omega = \frac{1}{RC}$  it exhibits a phase shift.
- C. It acts as a low pass filter.
- D. At  $\omega = \infty$  it lets nothing through.
- E. At  $\omega = 0$  it acts like a piece of wire.

24. Two acoustic signals A and B are present in a system. The powers of the signals are  $A = 10$  mW and  $B = 10 \mu\text{W}$ . The ratio of the two powers A/B expressed in dB is

- A. 30 dB
- B. -30 dB
- C. -60 dB
- D. 0 dB
- E. 60 dB

25. Evaluate the complex number expressed in polar notation by  $\frac{3\angle 120^\circ}{9\angle 150^\circ}$

- A.  $\frac{\sqrt{2}}{2}(1 + i)$
- B. none of the other answers
- C.  $\frac{1}{2\sqrt{3}} - \frac{1}{6}i$
- D.  $\frac{1}{3}\angle 30^\circ$
- E.  $6\angle -30^\circ$

26. Euler's Identity  $e^{j\theta} = \cos \theta + i \sin \theta$ , can be rewritten as  $\cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2}$  and  $\sin \theta = \frac{e^{j\theta} - e^{-j\theta}}{2j}$ . Using these, which of the following is an equivalent expression for  $\cos^2 \theta$ ?

- A.  $\frac{1 - \sin 2\theta}{2}$
- B.  $\frac{1 + \sin 2\theta}{2}$
- C.  $1 + \sin^2 \theta$
- D.  $\frac{1 - \cos 2\theta}{2}$
- E.  $\frac{1 + \cos 2\theta}{2}$

27. The following is *false* regarding square and triangle waves.

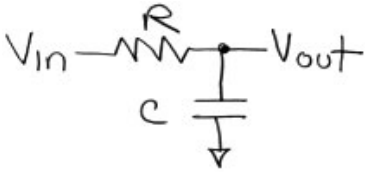
- A. Triangle waves result from integrating square waves, which boosts their lower harmonics.
- B. Triangle waves at 400 Hz into a speaker are audible, whereas square waves at 400 Hz are not.
- C. Square waves sound "harsher" than triangle waves because higher harmonics have greater relative amplitudes in the square wave as compared to the triangle wave.
- D. Neither wave can be actually created because infinitely high harmonics would be required.
- E. Square waves result from differentiating triangle waves, which boosts their higher harmonics.

28. The total complex impedance of this branch is



- A.  $\frac{1}{R} + \frac{1}{j\omega C}$
- B.  $R + j\omega C$
- C.  $1 + j\omega RC$
- D.  $\frac{1 + j\omega RC}{j\omega C}$
- E.  $\frac{1 + RC}{j\omega C}$

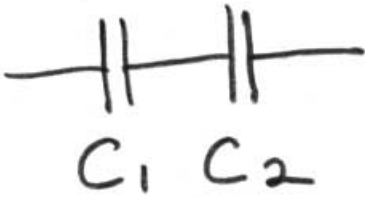
29. Which of the following is (are) true about the circuit below, given that  $R = 1\text{M}\Omega$  and  $C = .001\mu\text{F}$  and that  $V_{in}$  is sinusoidal at a particular frequency.



- I - The circuit is a low pass filter.
- II -  $|V_{out}| = \frac{1}{2}|V_{in}|$  at frequency  $f = 159.1$  Hz.
- III - The impedance of the capacitor increases as frequency increases.
- IV -  $V_{out}$  is also sinusoidal at the same frequency as  $V_{in}$

- A. I, II and III
- B. All are true.
- C. I, III, and IV
- D. II, III, and IV
- E. I, II and IV

30. What is the total capacitance of this branch if  $C_1 = C_2 = 10\mu\text{F}$ ?



- A.  $20 \mu\text{F}$
- B.  $0 \mu\text{F}$
- C.  $10 \mu\text{F}$
- D.  $\infty \mu\text{F}$
- E.  $5 \mu\text{F}$

31. The farad is a unit of

- A. energy
- B. charge
- C. voltage
- D. capacitance
- E. current

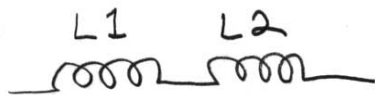
32. The energy stored in an inductor (coil) with 5 A through it

- A. is due to the charge built up within the coil.
- B. cannot be determined without more information.
- C. is linearly proportional to the current for a given inductance.
- D. depends on how long it took to achieve the current.
- E. equals 25 J.

33. Evaluate the complex number expressed as a complex exponential as  $-2e^{-j\frac{\pi}{4}}$

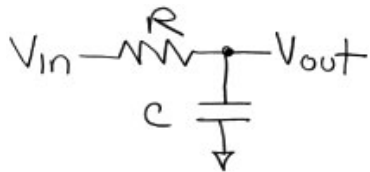
- A.  $\sqrt{2}(1 - j)$
- B.  $\sqrt{2}(j - 1)$
- C.  $2j$
- D. none of the other answers
- E.  $-2$

34. What is the total inductance of this branch if  $L_1 = 10 \mu\text{H}$ ,  $L_2 = 10 \mu\text{H}$ ?



- A.  $10 \mu\text{H}$
- B.  $100 \mu\text{H}$
- C.  $20 \mu\text{H}$
- D.  $5 \mu\text{H}$
- E.  $1 \mu\text{H}$

35. Which of the following is (are) true about the circuit below, given that  $R = 10 \text{ K}\Omega$  and  $C = 1 \mu\text{F}$ .



- I - The circuit is a low pass filter.
- II - At frequency  $\omega = 100$  radians per second, the impedances of the capacitor and the resistor are equal in magnitude.
- III - At very low frequencies the capacitor approaches an open circuit (infinite impedance).

- A. I, II and III
- B. None of the other answers is correct
- C. I and III
- D. I, and II
- E. II and III

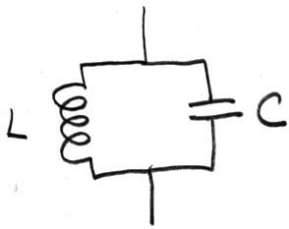
36. The following are true about safety and electricity, *except*

- A. Electricity usually kills by effecting the heart, so electricians are taught to use one hand near a high voltage.
- B. Hospital equipment often prevents direct connection between the patient-contacting equipment and 110 V by use of optical isolators and transformers.
- C. Alternating current (AC) is inherently safer than direct current (DC), which is why we use it to transmit power.
- D. High voltage can cause muscle contraction preventing the victim from releasing the wire.
- E. Skin resistivity is lowered by water, especially salt water.

37. The inductance of a coil produces a relationship between current and voltage described by  $V = L \frac{dI}{dt}$ . All of the following are true *except*

- A. To intentionally produce a spark, as in a spark-plug in your car, one uses a coil with a large inductance  $L$  and interrupts a large current by opening a switch.
- B. The equivalent equation for capacitance is  $I = C \frac{dV}{dt}$ , and energy in the capacitor is stored in the charge.
- C. The same relationship can also be written  $I = \frac{1}{L} \int V dt$
- D. Being basically a piece of wire, the impedance of an inductor is extremely low for high frequencies.
- E. Energy is stored in the magnetic field produced by the current, resulting in a tendency for the current to continue flowing unless opposed by a voltage.

38. Given that  $L = 10 \mu\text{H}$  and  $C = 100 \text{ pF}$ , which of the following is (are) true about the following branch?



- I - The impedance at both 0 Hz and  $\infty$  Hz is 0.
- II - The impedance at resonance is infinite.
- III - Resonance happens at  $\omega = \frac{1}{\sqrt{LC}}$ .

- A. None of the other answers is correct.
- B. II and III
- C. I and II
- D. I and III
- E. I, II, and III

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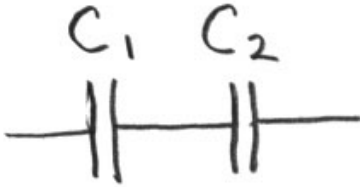
1. A 1 F capacitor begins with no charge on it. A current of 3 A is then flows one way through the capacitor for 4 seconds. A current of 2 A then flows the other way through the same capacitor for 2 seconds. The voltage on the capacitor immediately after that is

- A. 8 V
- B. 0 V
- C. not determinable from the data given.
- D. 5 V
- E. 16 V

**Explanation:**

[ *circuits0006.mcq* ]

2. What is the total capacitance of this branch if  $C_1 = 100 \mu\text{F}$ ,  $C_2 = 40 \mu\text{F}$ ?

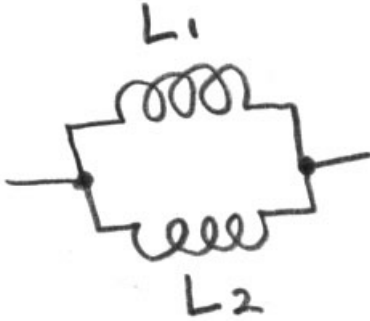


- A. 28.6  $\mu\text{F}$
- B. 140  $\mu\text{F}$
- C. 60  $\mu\text{F}$
- D. 7.14 mF
- E. 0  $\Omega$

**Explanation:**

[ *circuits0010.mcq* ]

3. What is the total inductance of this branch if  $L_1 = 5 \mu\text{H}$ ,  $L_2 = 10 \text{ H}$ ?



- A.  $5 \mu\text{H}$
- B.  $15 \mu\text{H}$
- C.  $3.3 \mu\text{F}$
- D.  $10 \text{ H}$
- E.  $2000 \mu\text{H}$

**Explanation:**

[ *circuits0011.mcq* ]

4. The property of inductance may best be described as

- A. the magnetic field surrounding a current providing something roughly akin to 'inertia' to that current.
- B. the mass of the electrons making them want to keep going in a straight line.
- C. electrons becoming concentrated in a piece of wire due to the surrounding magnetic field.
- D. electrons becoming concentrated on one plate causing electrons to leave the other plate.
- E. the magnetic field around a piece of wire interacting with the magnetic field of the earth.

**Explanation:**

[ *circuits0014.mcq* ]

5. A current is increased linearly from 1 A to 6 A over 10 seconds in a 100 mH inductor. During that time, what voltage would be measured across the inductor?

- A. 50 mV
- B. 5 V
- C. 50 V
- D. 0 V
- E. cannot be determined without knowing the other components in the circuit

**Explanation:**  $V = L \frac{dI}{dt}$

[ *circuits0016.mcq* ]

6. A condenser microphone is reported to have a signal-to-noise ratio of 60dB. This means that the ratio of the largest amplitude the microphone is capable of handling to the amplitude of background noise seen on the microphone's output is

- A. 1,000
- B. 1,000,000
- C. 60
- D. 60,000
- E. 30

**Explanation:**  $60 = 20\log_{10}(1000)$ .  
[ *circuits0021.mcq* ]

7. Evaluate the complex number expressed in polar notation by  $\frac{6\angle 90^\circ}{3\angle 45^\circ}$

- A.  $\sqrt{2}(1 + i)$
- B.  $\frac{\sqrt{2}}{2}(1 + i)$
- C.  $3\angle 2^\circ$
- D.  $2\angle 235^\circ$
- E. none of the other answers

**Explanation:**  $\frac{6\angle 90^\circ}{3\angle 45^\circ} = 2\angle 45^\circ$   
[ *circuits0022.mcq* ]

8. A current of 10 A is flowing in a 10 H inductor. What voltage would theoretically develop across the inductor if the current were stopped instantly?

- A.  $\infty$  V
- B. 50 V
- C. 100 V
- D. 0 V
- E. 1 V

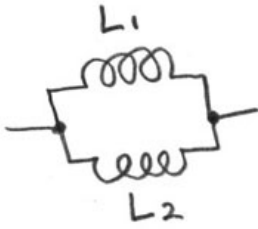
**Explanation:**  $V = L\frac{dI}{dt}$  so if  $dt = 0$  the voltage would theoretically be infinite. This is how large voltages are created in a car for the spark plugs.  
[ *circuits0023.mcq* ]

9. The following are true regarding square and triangle waves *except*, (or all are true).

- A. All are true.
- B. Square waves sound “harsher” than triangle waves because higher harmonics have greater amplitudes in the square wave as compared to the triangle wave.
- C. Square waves result from differentiating triangle waves, which boosts their higher harmonics.
- D. Each wave can be mathematically represented by a Fourier series of harmonics.
- E. Neither wave can be actually created because infinitely high harmonics would be required.

**Explanation:** The Fourier series is infinite, with the higher harmonics especially prominent in the square wave, giving it its harsh, buzzer-like quality.  
[ *circuits0024.mcq* ]

10. If  $L_1 = 150\text{mH}$ ,  $L_2 = 300\text{mH}$ , the circuit below is equivalent to



- A. a single 100mH inductor.
- B. a single 100mF capacitor.
- C. a single 450mH inductor.
- D. an RC filter
- E. none of the other answers.

**Explanation:** Inductors add in parallel as resistors do:  $L_{parallel} = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2}}$ .

[ *circuits0036.mcq* ]

11. If  $L = 250\text{mH}$ ,  $C = 300\mu\text{F}$ , the circuit below has zero impedance at what frequency (in Hz)?

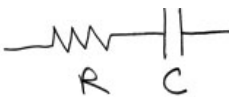


- A. 18.4 Hz
- B. 115 Hz
- C. 13.3 KHz
- D. 83.8 KHz
- E. 75 KHz

**Explanation:**  $\omega = \frac{1}{\sqrt{LC}}$ ;  $f = \omega/2\pi$ .

[ *circuits0037.mcq* ]

12. What is the total complex impedance (in ohms) of this branch if  $C = 0.1\mu\text{F}$ ,  $R = 10\text{K}\Omega$ ,  $f = 1000\text{Hz}$ ?

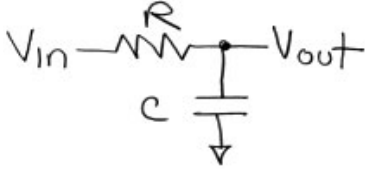


- A.  $10^4 - 1.59 \times 10^3 j$
- B.  $10^4 + 1.59 \times 10^3 j$
- C.  $10^4 - 10^4 j$
- D.  $10^4 + 10^4 j$
- E.  $10^4 - 10^7 j$

**Explanation:** The impedance of a capacitor is  $1/j\omega C$ ,  $\omega = 2\pi f$ . The unit of complex impedance is still ohms.

[ *circuits0039.mcq* ]

13. Which of the following is (are) true about the circuit below, given that  $R = 1\text{M}\Omega$  and  $C = .01\mu\text{F}$ .



I - The circuit is a high pass filter.

II -  $|V_{out}| = \frac{1}{2}|V_{in}|$  at frequency  $f = 15.9\text{ Hz}$ .

III - Since it is constructed from linear components, the circuit represents a linear system.

A. II and III

B. I, II and III

C. I, and II

D. I and III

E. III

**Explanation:**  $|R| = \left| \frac{1}{j\omega C} \right|$ ;  $\omega = \frac{1}{RC}$ ;  $f = \frac{\omega}{2\pi}$   
 [ circuits0040.mcq ]

14. Euler's Identity  $e^{j\theta} = \cos \theta + i \sin \theta$ , can be rewritten as  $\cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2}$  and  $\sin \theta = \frac{e^{j\theta} - e^{-j\theta}}{2j}$ . Using these, which of the following is an equivalent expression for  $\cos^2 \theta$ ?

A.  $\frac{1 + \cos 2\theta}{2}$

B.  $\frac{1 + \sin 2\theta}{2}$

C.  $\frac{1 - \cos 2\theta}{2}$

D.  $\frac{1 - \cos 2\theta}{2}$

E.  $\sin^2 \theta$

**Explanation:** Simply square  $\cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2}$  and regroup terms.  
 [ circuits0041.mcq ]

15. If  $L = 125\text{mH}$ ,  $C = 150\mu\text{F}$ , the circuit below has zero impedance at what frequency (in Hz)? (Recall that  $Z_L = j\omega L$  and  $Z_C = \frac{1}{j\omega C}$ , where frequency in Hz  $f = \omega/2\pi$ ).



A. 36.8 Hz

B. 230 Hz

C. 26.6 KHz

D. 167.6 KHz

E. 150 KHz

**Explanation:**  $\omega = \frac{1}{\sqrt{LC}}$ ;  $f = \omega/2\pi$ .  
 [ circuits0054.mcq ]

16. The inductance of a coil produces a relationship between current and voltage described by  $V = L \frac{dI}{dt}$ . All of the following are true *except*

- A. The larger the inductance  $L$ , the more rapid the change in current for a given voltage.
- B. Energy is stored in the magnetic field of the coil, making it take a voltage to change the current over time.
- C. The same relationship can also be written  $I = \frac{1}{L} \int V dt$
- D. To intentionally produce a spark, as in a spark-plug in your car, one uses a coil with a large inductance  $L$  and interrupts a large current by opening a switch.
- E. The equivalent equation for capacitance is  $I = C \frac{dV}{dt}$ , which basically says that to build up a charge on the capacitor over time takes a current.

**Explanation:** A larger inductance yields a *less* rapid change in current for a given voltage. The current demonstrates greater “inertia”. It takes more voltage to change it.

[ *circuits0071.mcq* ]

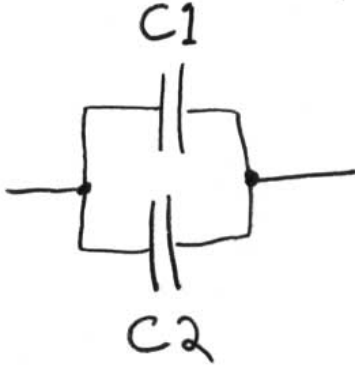
17. The current entering one wire into a perfect capacitor

- A. results in charge building up on one plate of the capacitor, which pushes charge off of the other plate out the other wire.
- B. is of much larger magnitude than the current leaving via the other wire, resulting in the buildup of voltage across the capacitor.
- C. can continue forever without experiencing the buildup of a voltage.
- D. experiences the buildup over time of a voltage pushing back against it proportional to the capacitance.
- E. cannot actually enter the capacitor at all, because no charge can accumulate on either of the individual plates inside the capacitor.

**Explanation:** The current entering one of the wires causes a charge to accumulate on one of the plates, pushing an equal charge off the other plate and out the other wire. A voltage will accumulate over time pushing back against the current, *inversely* proportional to the capacitance. A bigger capacitor can handle more current to produce the same voltage.

[ *circuits0072.mcq* ]

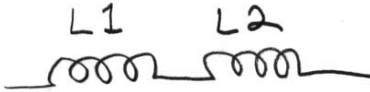
18. What is the total capacitance of this branch if  $C_1 = 20 \mu\text{F}$ ,  $C_2 = 20 \mu\text{F}$ ?



- A.  $40 \mu\text{F}$
- B.  $20 \mu\text{F}$
- C.  $10 \mu\text{F}$
- D.  $5 \mu\text{F}$
- E. Cannot be determined without knowing the frequency.

**Explanation:** Capacitance adds when in parallel, and is (ideally) independent of frequency.  
[ *circuits0074.mcq* ]

19. What is the total inductance of this branch if  $L_1 = 5 \mu\text{H}$ ,  $L_2 = 10 \mu\text{H}$ ?



- A.  $15 \mu\text{H}$
- B.  $5 \mu\text{H}$
- C.  $3.3 \mu\text{F}$
- D.  $10 \text{H}$
- E.  $2000 \mu\text{H}$

**Explanation:** Total inductance in series is  $L_1 + L_2$   
[ *circuits0075.mcq* ]

20. A current is decreased linearly from 10 A to 0 A over 0.01 seconds in a 5 H inductor. During that time, what voltage would be measured across the inductor?

- A. -5000 V
- B. -0.5 V
- C. -200 V
- D. -20 mV
- E. cannot be determined without knowing the other components in the circuit

**Explanation:**  $V = L \frac{dI}{dt}$   
[ *circuits0084.mcq* ]

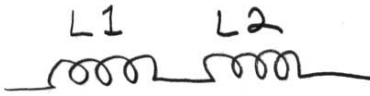
21. The following are true about the discharge of a capacitor with capacitance  $C$  through a resistor with resistance  $R$ , *except*

- A. Electrons leaving the positively charged plate of the capacitor are replaced by electrons entering the negatively charged plate.
- B. The time required to discharge to a certain percentage of the initial charge is proportional to  $RC$ .
- C. The discharge is governed by a first order differential equation similar to that governing radioactive decay of a certain initial amount of Carbon-14.
- D. Current will gradually decrease as the capacitor discharges.
- E. The energy initially stored in the capacitor is released as heat by the resistor.

**Explanation:** Electrons leaving the *negatively* charged plate of the capacitor are replaced (and only within the capacitor as a whole, not within a particular plate) by electrons entering the *positively* charged plate.

[ *circuits0086.mcq* ]

22. What is the total inductance of this branch if  $L_1 = 5$  H,  $L_2 = 10$  H?



- A.  $15 \mu\text{H}$
- B.  $5 \mu\text{H}$
- C.  $3.3 \mu\text{F}$
- D. 10 H
- E.  $2000 \mu\text{H}$

**Explanation:** Total inductance in series is  $L_1 + L_2$

[ *circuits0091.mcq* ]

23. The following are true regarding a circuit containing a resistor and a capacitor with the following relationship between input and output voltages

$$\frac{V_{out}}{V_{in}} = \frac{1}{1+j\omega RC}$$

at frequency  $\omega$ , *except*,

- A. It lets all frequencies through equally.
- B. It acts as a low pass filter.
- C. At  $\omega = 0$  it acts like a piece of wire.
- D. At  $\omega = \infty$  it lets nothing through.
- E. At  $\omega = \frac{1}{RC}$  it exhibits a phase shift.

**Explanation:** The circuit acts as a low pass filter, letting DC through completely, not letting infinitely high frequencies through at all, and shifting the phase of frequencies in between, such as  $\omega = \frac{1}{RC}$ , where it shifts by  $45^\circ$ .

[ *circuits0093.mcq* ]

24. Two acoustic signals A and B are present in a system. The powers of the signals are  $A = 10 \text{ mW}$  and  $B = 10 \mu\text{W}$ .

The ratio of the two powers A/B expressed in dB is

- A. 30 dB
- B. -30 dB
- C. 60 dB
- D. -60 dB
- E. 0 dB

**Explanation:** Since we are talking power, not amplitude,  $10\log_{10}\left(\frac{10^{-2}}{10^{-5}}\right) = 30$ .  
[ *circuits0095.mcq* ]

25. Evaluate the complex number expressed in polar notation by  $\frac{3\angle 120^\circ}{9\angle 150^\circ}$

- A.  $\frac{1}{2\sqrt{3}} - \frac{1}{6}i$
- B.  $\frac{\sqrt{2}}{2}(1 + i)$
- C.  $\frac{1}{3}\angle 30^\circ$
- D.  $6\angle -30^\circ$
- E. none of the other answers

**Explanation:**  $\frac{3\angle 120^\circ}{9\angle 150^\circ} = \frac{1}{3}\angle -30^\circ$   
[ *circuits0096.mcq* ]

26. Euler's Identity  $e^{j\theta} = \cos \theta + i \sin \theta$ , can be rewritten as  $\cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2}$  and  $\sin \theta = \frac{e^{j\theta} - e^{-j\theta}}{2j}$ . Using these, which of the following is an equivalent expression for  $\cos^2 \theta$ ?

- A.  $\frac{1 + \cos 2\theta}{2}$
- B.  $\frac{1 + \sin 2\theta}{2}$
- C.  $\frac{1 - \cos 2\theta}{2}$
- D.  $\frac{1 - \sin 2\theta}{2}$
- E.  $1 + \sin^2 \theta$

**Explanation:** Simply square  $\cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2}$  and regroup terms.  
[ *circuits0097.mcq* ]

27. The following is *false* regarding square and triangle waves.

- A. Triangle waves at 400 Hz into a speaker are audible, whereas square waves at 400 Hz are not.
- B. Square waves sound "harsher" than triangle waves because higher harmonics have greater relative amplitudes in the square wave as compared to the triangle wave.
- C. Square waves result from differentiating triangle waves, which boosts their higher harmonics.
- D. Triangle waves result from integrating square waves, which boosts their lower harmonics.
- E. Neither wave can be actually created because infinitely high harmonics would be required.

**Explanation:** The higher harmonics especially prominent in the square wave, giving it its harsh, buzzer-like quality. The actual Fourier transform for either is infinite and thus neither can actually be created in the physical world.  
[ *circuits0098.mcq* ]

28. The total complex impedance of this branch is

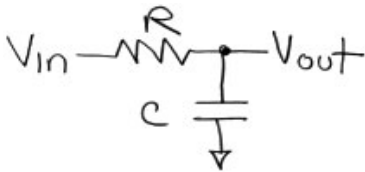


- A.  $\frac{1+j\omega RC}{j\omega C}$
- B.  $\frac{1+RC}{j\omega C}$
- C.  $1 + j\omega RC$
- D.  $R + j\omega C$
- E.  $\frac{1}{R} + \frac{1}{j\omega C}$

**Explanation:** The total impedance is that of the capacitor,  $\frac{1}{j\omega C}$ , plus that of the resistor, R. Combining terms yields a reassuring RC term in the numerator.

[ circuits0103.mcq ]

29. Which of the following is (are) true about the circuit below, given that  $R = 1M\Omega$  and  $C = .001\mu F$  and that  $V_{in}$  is sinusoidal at a particular frequency.



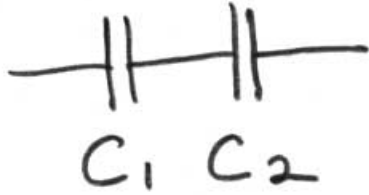
- I - The circuit is a low pass filter.
- II -  $|V_{out}| = \frac{1}{2}|V_{in}|$  at frequency  $f = 159.1$  Hz.
- III - The impedance of the capacitor increases as frequency increases.
- IV -  $V_{out}$  is also sinusoidal at the same frequency as  $V_{in}$ .

- A. I, II and IV
- B. I, II and III
- C. I, III, and IV
- D. II, III, and IV
- E. All are true.

**Explanation:**  $|R| = \frac{1}{j\omega C}$ ;  $\omega = \frac{1}{RC}$ ;  $f = \frac{\omega}{2\pi}$ . The circuit is a low pass filter and a linear system, so a sinusoid only changes phase and amplitude, not frequency. The impedance of a capacitor,  $\frac{1}{j\omega C}$ , decreases with frequency.

[ circuits0105.mcq ]

30. What is the total capacitance of this branch if  $C_1 = C_2 = 10\mu\text{F}$ ?



- A.  $5\ \mu\text{F}$
- B.  $20\ \mu\text{F}$
- C.  $\infty\ \mu\text{F}$
- D.  $0\ \mu\text{F}$
- E.  $10\ \mu\text{F}$

**Explanation:** Total capacitance in series is  $\frac{1}{\frac{1}{C_1} + \frac{1}{C_2}}$   
[ *circuits0100.mcq* ]

31. The farad is a unit of

- A. capacitance
- B. voltage
- C. current
- D. energy
- E. charge

**Explanation:** A farad is a certain amount of capacitance, the amount that results in the accumulation of 1 volt when charging at 1 ampere for 1 second.

[ *circuits0111.mcq* ]

32. The energy stored in an inductor (coil) with 5 A through it

- A. cannot be determined without more information.
- B. is due to the charge built up within the coil.
- C. is linearly proportional to the current for a given inductance.
- D. equals 25 J.
- E. depends on how long it took to achieve the current.

**Explanation:** Answer A is correct, since one needs to know the inductance to determine energy. The energy is due to the current, not charge, and is independent of how long it took to achieve the current. The energy is proportional to the square of the current for a given inductance,  $E = \frac{1}{2}LI^2$ .

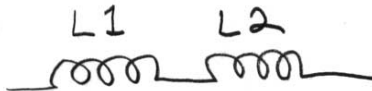
[ *circuits0114.mcq* ]

33. Evaluate the complex number expressed as a complex exponential as  $-2e^{-j\frac{\pi}{4}}$

- A.  $\sqrt{2}(j - 1)$
- B.  $\sqrt{2}(1 - j)$
- C.  $-2$
- D.  $2j$
- E. none of the other answers

**Explanation:**  $-2e^{-j\frac{\pi}{4}} = -2\left(\frac{1}{\sqrt{2}} + \frac{-j}{\sqrt{2}}\right) = \sqrt{2}(j - 1)$ .  
[ circuits0115.mcq ]

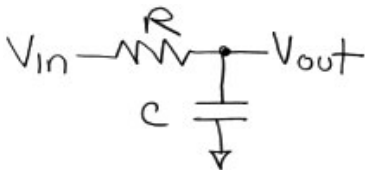
34. What is the total inductance of this branch if  $L_1 = 10 \mu\text{H}$ ,  $L_2 = 10 \mu\text{H}$ ?



- A.  $20 \mu\text{H}$
- B.  $5 \mu\text{H}$
- C.  $100 \mu\text{H}$
- D.  $10 \mu\text{H}$
- E.  $1 \mu\text{H}$

**Explanation:** Total inductance in series is  $L_1 + L_2$   
[ circuits0120.mcq ]

35. Which of the following is (are) true about the circuit below, given that  $R = 10 \text{ K}\Omega$  and  $C = 1 \mu\text{F}$ .



- I - The circuit is a low pass filter.
- II - At frequency  $\omega = 100$  radians per second, the impedances of the capacitor and the resistor are equal in magnitude.
- III - At very low frequencies the capacitor approaches an open circuit (infinite impedance).

- A. I, II and III
- B. II and III
- C. I, and II
- D. I and III
- E. None of the other answers is correct

**Explanation:** Impedance for capacitor is  $Z = \frac{1}{j\omega C}$ .  $|R| = \left|\frac{1}{j\omega C}\right|$  when  $\omega = \frac{1}{RC}$ ;  
[ circuits0122.mcq ]

36. The following are true about safety and electricity, *except*

- A. Alternating current (AC) is inherently safer than direct current (DC), which is why we use it to transmit power.
- B. Electricity usually kills by effecting the heart, so electricians are taught to use one hand near a high voltage.
- C. Hospital equipment often prevents direction connection between the patient-contacting equipment and 110 V by use of optical isolators and transformers.
- D. Skin resistivity is lowered by water, especially salt water.
- E. High voltage can cause muscle contraction preventing the victim from releasing the wire.

**Explanation:** AC is actually more dangerous than DC, because the skin impedance is lower at 60 Hz than at 0 Hz. We use AC because it permits the use of transformers to step-up and step-down the voltage for long range transmission.

[ *circuits0123.mcq* ]

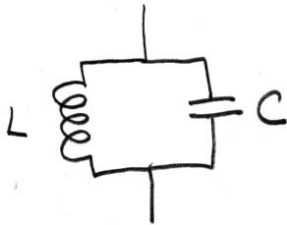
37. The inductance of a coil produces a relationship between current and voltage described by  $V = L \frac{dI}{dt}$ . All of the following are true *except*

- A. Being basically a piece of wire, the impedance of an inductor is extremely low for high frequencies.
- B. Energy is stored in the magnetic field produced by the current, resulting in a tendency for the current to continue flowing unless opposed by a voltage.
- C. The same relationship can also be written  $I = \frac{1}{L} \int V dt$
- D. To intentionally produce a spark, as in a spark-plug in your car, one uses a coil with a large inductance  $L$  and interrupts a large current by opening a switch.
- E. The equivalent equation for capacitance is  $I = C \frac{dV}{dt}$ , and energy in the capacitor is stored in the charge.

**Explanation:** The impedance of an inductor is  $Z = j\omega L$ , and thus increases with frequency.

[ *circuits0125.mcq* ]

38. Given that  $L = 10 \mu\text{H}$  and  $C = 100 \text{ pF}$ , which of the following is (are) true about the following branch?



I - The impedance at both 0 Hz and  $\infty$  Hz is 0.

II - The impedance at resonance is infinite.

III - Resonance happens at  $\omega = \frac{1}{\sqrt{LC}}$ .

- A. I, II, and III
- B. None of the other answers is correct.
- C. I and II
- D. II and III
- E. I and III

**Explanation:** The impedance of the branch is  $\omega = \frac{1}{j\omega C + \frac{1}{j\omega L}} = \frac{j\omega L}{1 - \omega^2 LC}$ .

[ *circuits0129.mcq* ]