Circuit Lab Key

Division B

Scioly.org Test Exchange

How to Grade

- Grade multiple choice questions as you normally would.
- If any matching or fill in the blank is misspelled, then give points if the phrase is similar to the one present on the key.
- Give points for any work shown on free response up to your own discretion.
- If calculated answers are within ± 5% of the answer shown on the answer key (inclusive), then give full points.
- If responses are similar, paraphrased, or have the right idea as the one shown on the key, give full points.

Section I: Matching

Write the last name of the scientist on the answer line provided that best describes a discovery, theory, or invention made by that scientist in the list of statements below. Each question in this section is worth 1 point.

POSSIBLE ANSWERS:		
Volta	Kirchhoff	Tesla
Ampere	Faraday	
Coulomb	Ohm	

1. (1 point) Wrote a memoir on his experiments using one of his inventions, the torsion balance.

1. **Coloumb**

2. (1 point) Disagreed with Galvani about the concept of electricity.

2. **Volta**

3. (1 point) Showed that two parallel wires carrying current in the same direction attract one another.

3. **Ampere**

4. (1 point) Invented the first electromagnetic generator, also known as a dynamo.

4. **Faraday**

5. (1 point) Invented the first induction motor.

5. **Tesla**

6. (1 point) Discovered that the algebraic sum of currents entering a node is equivalent to the sum of currents exiting that same node.

6. **Kirchhoff**

7. (1 point) The only one in the rules besides Ampere whose name is inscribed on the Eiffel Tower.

7. **Coulomb**

Section II: Multiple Choice

8. (1 point) According to Ohm's Law, the electric current of a circuit is _____ proportional to the electrical potential, and _____ proportional to the resistance.

   A. inversely, directly

   B. directly, indirectly

   C. inversely, indirectly

   D. directly, inversely

9. (1 point) Based on your answer from question 2, how would you solve for the electrical potential, given the electric current and resistance?

   A. V = IR

   B. V = $\frac{I}{R}$

   C. V = $\frac{R}{I}$

   D. V = $\frac{IR}{2}$

10. (1 point) What is the relationship between energy and power?

    A. They are directly proportional.

    B. They are inversely proportional.

    C. They are not proportional.

    D. None of the above.

11. (1 point) KCL is based off of the law of conservation of _____, while KVL is based off of the law of conservation of _____.

    A. mass, energy

    B. electric current, energy

    C. charge, energy

    D. charge, voltage

12. (1 point) A battery is connected in series with three resistors. If the voltage drop of the combined three resistors is subtracted from the voltage of the battery, what is the value of the resulting voltage?

    A. 0 V

    B. 1 V

    C. 2 V

    D. 3 V

13. (1 point) The formula for drift velocity through any object is _____.

    A. $u = \mu E^2$

    B. $u = \mu / E$

    C. $u = \mu E$

    D. $u = \mu EV$

14. (1 point) Currents of _____ or higher can be considered lethal and even cause death.

    A. 20 mA

    B. 100 mA

    C. 50 mA

    D. 200 mA

15. (1 point) What is the RMS voltage of a wall outlet in a typical home in Algeria?

    A. 120 V

    B. 220 V

    C. 230 V

    D. 240 V

16. (1 point) Which of the following types of resistors are used for power and high precision applications?

    A. metal oxide film

    B. wirewound

    C. carbon composition

    D. carbon film

17. (1 point) What is the maximum voltage that a typical carbon film resistor can handle?

    A. 250 V

    B. 200 V

    C. 100 V

    D. 350-500 V

18. (1 point) Identify the temperature coefficient of a resistor with the bands green, yellow, red, orange, brown, and red.

    A. 100 ppm/K

    B. 10 ppm/K

    C. 50 ppm/K

    D. 250 ppm/K

19. (1 point) Listed below are some materials. Identify the material with the most resistance out of the following.

    A. asphalt

    B. high-temperature glass

    C. dirty water

    D. copper

20. (1 point) Two charges, q_1 and q_2 respectively, have a charge +Q. If the distance between them triples, the charge of q_1 is doubled, and the charge of q_2 is quadrupled, by what factor does the electrostatic force between the two charges increase?

    A. increases by a factor of 2

    B. increases by a factor of 8/9

    C. increases by a factor of 9/8

    D. increases by a factor of 7/9

21. (1 point) What is the mass of a single proton and a single electron in grams, respectively?

    A. 1.67×10^{-27}; 9.11×10^{-28}

    B. 9.11×10^{-28}; 1.67×10^{-24}

    C. 1.67×10^{-24}; 9.11×10^{-28}

    D. 1.77×10^{-24}; 9.11×10^{-28}

22. (1 point) Protons and neutrons are made up of different quarks. Determine which quarks, and the amount that makes up each.

    A. proton is 2 u, 2 d; neutron is 1 u, 4 d

    B. proton is 2 c, 1 d; neutron is 1 u, 2 d

    C. proton is 2 b, 1 d; neutron is 1 u, 2 t

    D. proton is 2 u, 1 d; neutron is 1 u, 2 d

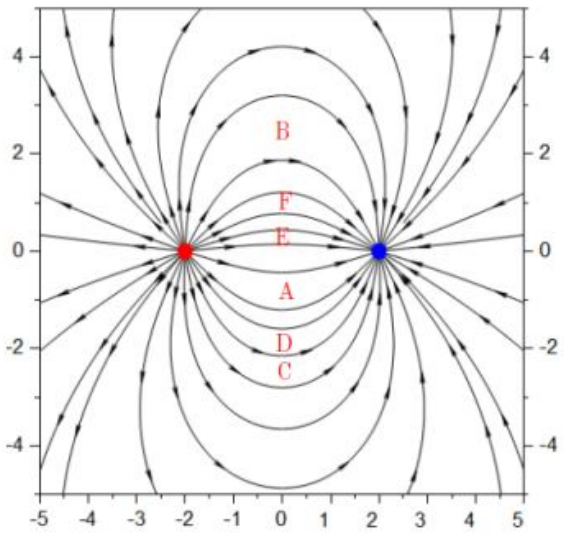
23. (1 point) Isolines are where the voltage for any particle is _____. They are also referred to as _____, and are _____ to electric field lines.

    A. constant, equipotentials, parallel

    B. varied, equipotentials, perpendicular

    C. constant, equipotentials, perpendicular

    D. varied, equipotentials, parallel



24. (1 point) Using the image shown above, rank the locations A through E in terms of electric field strength, from strongest to weakest.

    A. B, A, C, D, F, E

    B. B, A, C, D, E, F

    C. A, B, C, D, F, E

    D. E, F, D, C, A, B

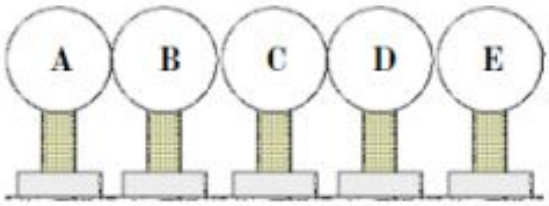
25. (1 point) Based on your answer from question 24, the electric field in the diagram to the right is _____ and the electric field of a monopole is _____. Electric fields are _____.

    A. uniform, uniform, scalars

    B. not uniform, uniform, vectors

    C. not uniform, not uniform, vectors

    D. not uniform, uniform, scalars



26. (2 points) 5 neutrally conducting spheres are all lined up, but are not in contact with one another, labeled from A to E, as shown in the image above. A rod with 3.00×10^2 electrons and 40 protons is brought close, but not touching sphere A. All the spheres are then separated and the rod is removed. Determine the charge of each sphere after this event occurs.
    A. A- positive, B- negative, C- positive, D- negative, E- negative
    B. A- positive, B- negative, C- positive, D- negative, E- positive
    C. A- negative, B- positive, C- negative, D- positive, E- negative
    D. A- negative, B- negative, C- positive, D- negative, E- positive

27. (1 point) A balloon is rubbed against a piece of cloth. Determine the charge of the balloon and the cloth.
    A. balloon is negatively charged; cloth is positively charged
    B. balloon is positively charged; cloth is negatively charged.
    C. both positively charged
    D. both negatively charged

28. (1 point) Using the scenario from question 21, identify the name of the interactions between the balloon and cloth.
    A. grounding
    B. triboelectric charging
    C. conduction charging
    D. induction charging

29. (1 point) Which of the following do not use static electricity?
    A. printers
    B. air filters
    C. photocopiers
    D. none of the above

30. (1 point) Which of the following is not a hazard of static electricity?
    A. electric shock
    B. explosion
    C. toxic gases
    D. high current

31. (2 points) Two parallel plates make up a capacitor with an area A and a distance D. If the distance between the two plates decreases by a factor of two, and the area of each plate is increased by a factor of 2, by what factor does the capacitance of this capacitor increase or decrease?
    A. decreases by a factor of 1
    B. increases by a factor of 4
    C. increases by a factor of 8
    D. increases by a factor of 4

32. (1 point) What is the dielectric constant of teflon? Does this substance have a higher dielectric constant than water?
    A. 2.25; no
    B. 2.1; yes
    C. 3.18; no
    D. 2.1; no

33. (1 point) When a parallel plate capacitor connected to a battery has a decrease in plate separation, which of the following variables of the capacitor increases?
    A. charge
    B. voltage
    C. electric field
    D. capacitance

34. (1 point) A geographic south pole is a magnetic _____ pole and a geographic north pole is a magnetic _____ pole.
    A. south, north
    B. north, south
    C. south, south
    D. north, north

35. (1 point) Identify which of the following metals have a curie temperature of 1000 K or higher.

    A. nickel

    B. iron

    C. cobalt

    D. gadolinium

36. (1 point) Which of the following is not a property of magnetic field lines?

    A. Magnetic field lines have closed loops.

    B. The density of magnetic field lines are proportional to its strength.

    C. Magnetic field lines terminate at magnetic materials.

    D. The magnetic field lines of a magnet start from the north pole and end at the south pole.

37. (1 point) Determine the direction of an opposing magnetic field created by a current flowing through a wire which is induced by a magnetic field rotating counterclockwise.

    A. clockwise

    B. counterclockwise

    C. right

    D. left

38. (1 point) When a magnetic material is saturated, _____.

    A. External fields can no longer increase their magnetization.

    B. Any applied external fields now decrease their magnetization.

    C. External fields increase their magnetization very significantly.

    D. The curie temperature of the material can now increase.

39. (1 point) The magnetic field strength of a white dwarf star in G is

    A. 10^8

    B. 1,000

    C. 0.01

    D. 10^{-12}

40. (1 point) Which of the following types of steel are not magnetic?

    A. austenitic stainless

    B. ferritic stainless

    C. non-stainless

    D. martensitic stainless

41. (1 point) Which concept explains how transformers work?

    A. magnetic field

    B. electromagnetic induction

    C. electromagnetic radiation

    D. power

42. (1 point) Why is it important for a transformer to have a core made up of a metal such as iron instead of a metal such as copper instead? **Tiebreaker**

    A. The malleability of any metal allows more voltage to be increased or decreased across the primary and secondary coils.

    B. A build-up of electrons in an iron core links the primary and secondary coil together, inducing a voltage in the secondary.

    C. A magnetic field links the primary and secondary coil together, inducing a voltage in the secondary. Therefore, a stronger magnetic field would link the two coils together more efficiently and induces a voltage in the secondary also more efficiently.

    D. The equipotential lines around any electrons prevent any interruptions when a voltage is being changed from a primary to secondary coil.

43. (1 point) In a step-down transformer, the voltage _____ from primary to secondary coil. In a step-up transformer, the electric current _____ from primary to secondary coil.

    A. decreases, decreases

    B. decreases, increases

    C. increases, decreases

    D. increases, increases

44. (1 point) Transformers can function with _____.

A. both AC and DC

B. only DC

C. neither AC and DC

D. only AC

45. (1 point) Which process produces the electrical current in a coil of wire in a DC motor?

A. The brushes make moving contact with a split ring.

B. The rotor of a DC motor turns, creating electric current in the process.

C. The magnet of the motor creates magnetic fields, which create electrical current in the coil.

D. The brushes make moving contact with the commutator.

46. (1 point) A stator is the stationary part of an AC motor. Why is the stator an important part of the motor, despite being stationary? **Tiebreaker**

A. The stator prevents the motor from overheating.

B. The stator supplies the electric current necessary to turn a motor.

C. There is no purpose for the stator in a motor.

D. The stator creates a rotating magnetic field, which allows the motor to function.

47. (1 point) Motors convert _____ to _____ energy and generators convert _____ to _____ energy.

A. potential, kinetic, mechanical, electrical

B. electrical, kinetic, mechanical, electrical

C. electrical, mechanical, mechanical, electrical

D. electrical, mechanical, electrical, mechanical

48. (1 point) Circle the following types of generators which are DC and underline the types of generators which are AC.

A. induction generator (underlined)

B. MHD generator (circled)

C. VSCF generator (underlined)

D. linear alternator generator (underlined)

E. homopolar generator (circled)

49. (1 point) Which of the following is not a type of diode?

A. avalanche

B. zener

C. solar

D. laser

50. (1 point) The resistance of an ideal diode in reverse bias is _____.

A. 5.55 Ω

B. ∞ Ω

C. 1.75 Ω

D. 0 Ω

E. 2 Ω

F. 3.5 Ω

51. (1 point) The resistance of an ideal diode in forward bias is _____.

A. 5.55 Ω

B. ∞ Ω

C. 1.75 Ω

D. 0 Ω

E. 2 Ω

F. 3.5 Ω

52. (1 point) An LED with a wavelength of 676 nm most likely is the color _____.

A. orange

B. green

C. red

D. blue

53. (1 point) What color LED uses the semiconductor aluminum nitride to give it its color?

A. pink

B. red

C. ultraviolet

D. infrared

54. (1 point) The first LED was created in _____ and was the color _____.

    A. 1953, green

    B. 1887, red

    C. 1975, ultraviolet

    D. 1962, red

55. (1 point) What is the similarity between a diode and a rectifier?

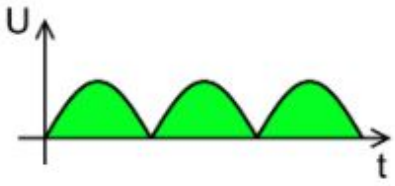
    A. They both are circuits.

    B. The photoelectric effect explains how they both work.

    C. They both are singular electrical components.

    D. They both convert DC to AC.

    E. They both convert AC to DC.



56. (1 point) The graph above represents the voltage output for a _____ rectifier.

    A. single phase half-wave

    B. three phase full-wave

    C. single phase full-wave

    D. three phase half-wave

57. (2 points) A charge of 4 C passes through a wire with an energy value of 8 J in 2 seconds. Calculate the power loss through this wire in kilowatts.

    A. 0.008

    B. 0.004

    C. 4

    D. 0.007

58. (2 points) A circuit comprises two subcircuits, labeled A and B, respectively. A voltage of -5.0 mV is applied across both subcircuits, along with an electric current of 5.0 C/s flowing from subcircuit B to A. What is the power consumption by each subcircuit?

    A. A: -0.025 W, B: 0.025 W

    B. A: -25 W, B: -25 W

    C. A: -0.25 W, B: 0.025 W

    D. A: -0.025 W, B: -0.025 W

59. (2 points) A cylinder-shaped wire has a resistivity of 0.00605 Ω-m, the radius of the cross-section of the wire is 1.05 cm and a length of 1.50 m. What is the resistance of the wire in mΩ?

    A. 25200 mΩ

    B. 56250 mΩ

    C. 26205 mΩ

    D. 26200 mΩ

60. (2 points) One AA battery is connected in series with a 15 Ω resistor and a 35 Ω resistor. This branch of the circuit is connected in parallel with a resistor labeled X with an unknown resistance. If the total current generated by this circuit is 3.50 A, then what is the value of the resistance of resistor X? **Tiebreaker**

    A. 0.432 Ω

    B. 0.43 Ω

    C. 0.47 Ω

    D. 1.34 Ω

61. (2 points) A solenoid has a current of 5.30 A passing through it and has a length of 40.0 cm with 30.0 turns. If the relative permeability of the core of the solenoid is 220.0 H/m, what is the magnetic flux of the center of the solenoid? **Tiebreaker**

    A. 0.110 T

    B. 2.07×10^{-6} T

    C. 11.0×10^{-5} T

    D. 2.83×10^{-4} T

Section III: Short Response

62. (12 points) Fill out the following table below. Each blank is worth 0.5 points.

Unit	Expressed in Base SI	Quantity Measured
Volt	$kg \times m^2 \times s^{-3} \times A^{-1}$	voltage or electric potential
Ampere	A or C/s	electric current
Siemen	$kg^{-1} \times m^{-3} \times s^3 \times A^2$	electric conductance
Ohm	$kg \times m^2 \times s^{-3} \times A^{-2}$	electric resistance
Farad	$kg^{-1} \times m^{-2} \times s^4 \times A^2$	capacitance
Watt	$kg \times m^2 \times s^{-3}$	power
Joule	$kg \times m^2 \times s^{-2}$	work or energy
Coulomb	$A \times s$	electric charge
Newton	$kg \times m \times s^{-2}$	force
Tesla	$kg \times s^{-2} \times A^{-1}$	magnetic flux density
Weber	$kg \times m^2 \times s^{-2} \times A^{-1}$	magnetic flux
Henry	$kg \times m^2 \times s^{-2} \times A^{-2}$	inductance

63. (5 points) A table showing different elements is shown below. On the blank to the right of each element, write the type of magnetism that each element exhibits without the influence of a magnetic field. Each blank is worth 0.5 points.

Element	Magnetic Property	Element	Magnetic Property
Rubidium	paramagnetism	Nickel	ferromagnetism
Aluminum	paramagnetism	Osmium	paramagnetism
Antimony	diamagnetism	Flourine	diamagnetism
Copper	diagmagnetism	Hydrogen	diagmagnetism
Chromium	antiferromagnetism	Potassium	paramagnetism

64. (3 points) List out three ways to increase the inductance of an inductor.

Answeres may vary. Example shown below.

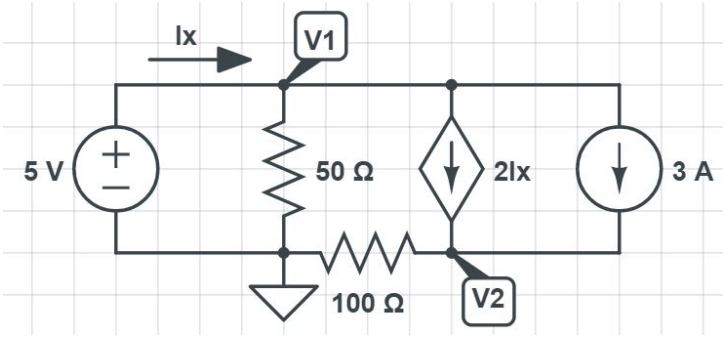
- Increase the number of loop turns of the inductor. (1 point)
- Increase the diameter of each loop turn of the inductor. (1 point)
- Insert a ferromagnetic core into the inductor and/or increase the diameter of the ferromagnetic core (if there is already one). (1 point)

65. (2 points) Inductors store **energy** in the form of **magnetic fields**.

*Each blank is worth one point.

Section IV: Free Response

66. (5 points) Find the magnitude of V_1 and V_2 in V shown in the circuit shown below. Do not give units and round your answer to 3 significant figures.



Solution:

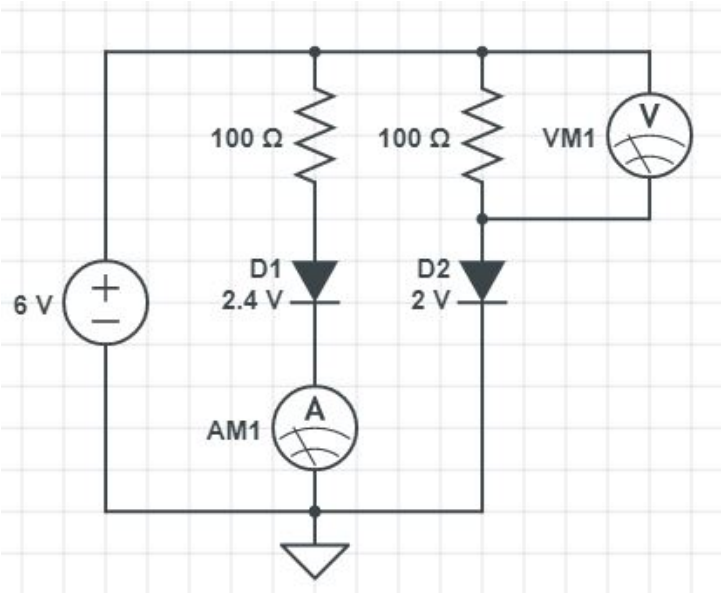
You can already tell $V_1 = 5$ V from looking at the circuit. Using KCL, the equation $i_x = \frac{5}{50\Omega} + 2i_x + 3$ can be formulated, where i_x = -3.1 A. Now, all that's left to do is write the equation for V_2.

$$2(-3.1) + 3 - \frac{V_2}{100\Omega} = 0$$

V_1 = 5 V (2 points)

V_2 = -320 V (3 points)

67. (11 points) Use the following circuit to answer parts (a) through (c). Assume both diodes are ideal, along with the voltmeter and ammeter. Each part is 2 points each, except for part (c), which is worth 5 points.



(a) Find the reading of the ammeter in mA. Round to 2 significant figures.

Solution:
The current read by the ammeter will be the same as the current flowing through the 100 Ω resistor in the same branch because the two are in series.
$\frac{6\text{V}-2.4\text{V}}{100\Omega} = 36$ mA

(b) Find the reading of the voltmeter in V. Round to 4 significant figures.

Solution:
The voltage across the 100 Ω resistor is equivalent to the voltage across the entire branch subtracted by the forward voltage of D_2.
6 V − 2.4 V = 3.6 V

(c) What is the forward current flowing through D_1 and D_2? Why does the forward current through each diode differ?

Solution:
The forward current through D_1 and D_2 will be equivalent to the 100 Ω resistors above them because they are in series.
$\frac{6\text{V}-2.4\text{V}}{100\Omega} = 36.00$ mA is the forward current flowing through D_1. (2 points)
$\frac{6\text{V}-2\text{V}}{100\Omega} = 30.00$ mA is the forward current flowing through D_2. (2 points)
The forward current through each diode differs because the forward voltage across each diode is different, resulting in a different voltage drop across the 100 Ω resistors above them, which affects the forward current through each diode. (1 point)

(d) Find the total power used by the circuit in mW. Round to 3 significant figures.

Solution:
The total power used by the circuit will be equivalent to the sum of the power used by the diodes and resistors. This is also equivalent to the product of the total current and the voltage of the battery because the battery supplies the power used for the circuit.
(36 mA + 30 mA) × 6 V = 396 mW

68. (3 points) Why might it not be best to use thin, superconductive wires in high current applications?

Solution:
Superconductive wires have zero resistance. (1 point) This makes it very dangerous to use in high current applications because this can create a short circuit. (1 point) In addition, because the wires are thin, these wires will be melted by the amount of heat energy given off by this amount of current. (1 point)

69. (3 points) Find the potential energy between two electrons separated by a distance of 1 m. Round your answer to 2 significant figures.

Solution:
Using the equation $U = k\frac{q_1 q_2}{r}$, the electric potential energy between the two electrons can be found.
$U = 8.988 \times 10^9 \ \frac{(-1.602\times10^{-19}\ \text{C})^2}{1\ \text{m}} = 2.3 \times 10^{-28}\ \text{J}$

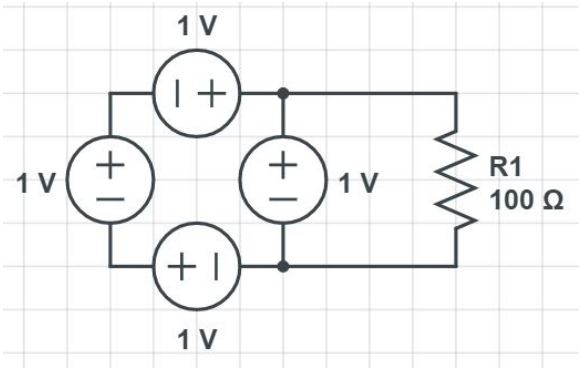
70. (3 points) After how many time constants is an ideal capacitor in an RC circuit fully charged? How is this different from an actual capacitor in the same setting?

Solution:
An ideal capacitor in an RC circuit is fully charged after 5 time constants. (1 point) This is different from an actual capacitor in the same setting because actual capacitors are never fully charged. (2 points)

71. (3 points) I touch a live wire in midair, but not much happens. Why is it safer for me to touch a live wire in midair than if I was standing on the ground?

Solution:
If you're touching a live wire in midair, electrons have no place to travel via your body. (1 point) When you're standing on the ground, the ground provides a place for electrons to travel via your body, making it more dangerous. (2 points)

72. (4 points) Why is it impossible for the circuit shown below to exist? **Tiebreaker**



Solution:

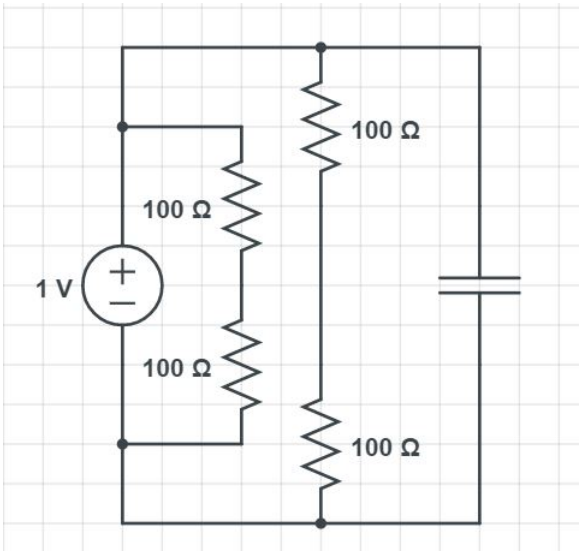
Analyzing the circuit, the left branch contains three 1 V batteries in series and the middle branch contains one 1 V battery. These two branches are in parallel with one another. (2 points) According to basic circuit laws, two branches in parallel must have the same voltage, but the left branch has a total voltage of 3 V, while the middle branch has a voltage of 1 V; these voltages are different. Therefore, this circuit cannot exist. (2 points)

73. (3 points) Depending on its resistance, a component can have a voltage across it even if no current is flowing through it. Explain how an ideal voltmeter demonstrates this.

Solution:

An ideal voltmeter has infinite resistance, so no current flows through the voltmeter. (2 points) When the voltmeter is connected in parallel with any given component however, it still has the same voltage as that component as shown by the reading it gives. (1 point)

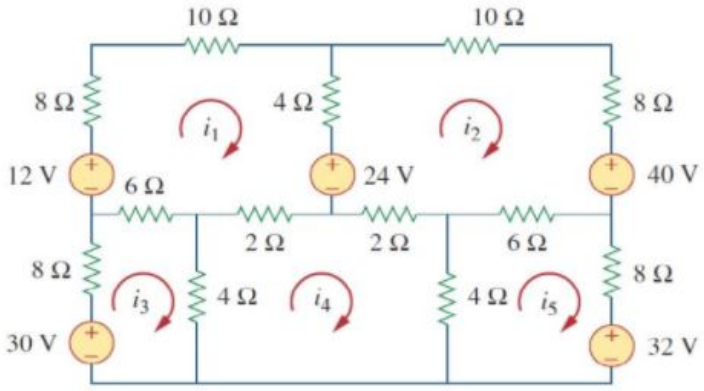
74. (4 points) Is it possible to determine the RC time constant of the circuit below? If so, explain how. **Tiebreaker**



Solution:

It's possible to determine the RC time constant of this circuit even without the capacitance of the capacitor because the time constant is equal to 0. Essentially, this isn't an RC circuit. (2 points) The capacitor acts as a wire that shorts all the 100 Ω resistors as soon as time = 0, making the resistance of the circuit ineffective. (2 points)

75. (28 points) Use the following circuit shown below for parts (a) and (b). Part (a) is worth 15 points and part (b) is worth 10 points, and part (c) is worth 3 points.



(a) Calculate the magnitude of current in loops i_1, i_2, i_3, i_4 and i_5 in A. Round to 2 significant figures.

Solution:

We can use mesh circuit analysis for this circuit, setting up an equation for each of the 5 loops.

Loop $i_1 \rightarrow 12 - 8i_1 - 10i_1 - 4(i_1 - i_2) - 24 - 2(i_1 - i_4) - 6(i_1 - i_3) = 0$

Loop $i_2 \rightarrow 24 - 4(i_2 - i_1) - 10i_2 - 8i_2 - 40 - 6(i_2 - i_5) - 2(i_2 - i_4) = 0$

Loop $i_3 \rightarrow 30 - 8i_3 - 6(i_3 - i_1) - 4(i_3 - i_4) = 0$

Loop $i_4 \rightarrow 4(i_4 - i_3) + 2(i_4 - i_1) - 2(i_4 - i_2) + 4(i_4 - i_5) = 0$

Loop $i_5 \rightarrow -32 - 4(i_5 - i_4) - 6(i_5 - i_2) - 8i_5 = 0$

$i_1 = -0.22$ A (3 points)

$i_2 = -0.99$ A (3 points)

$i_3 = 1.6$ A (3 points)

$i_4 = -0.085$ A (3 points)

$i_5 = -2.1$ A (3 points)

(b) Calculate the thevenin voltage and resistance of this circuit with respect to the 30 V battery. Round to 3 significant figures.

Solution:
To find the thevenin resistance of the circuit, replace all batteries with shorts and remove the 30 V source. Using methods to solve for equivalent of series and parallel resistors, as well as $\Delta-$Y or Y$-\Delta$ transformations, the thevenin resistance can be found.
$R_{th} = 1.96\ \Omega$
Finding thevenin voltage is best using mesh here. The mesh equations are the same as part (a), except that there's no loop i_3 and equations for loop i_1 and i_4 don't include i_3 as part of the equation anymore as a result.
$V_{th} = 10.0$ V

(c) Why is it best to use mesh current analysis for part (a) instead of superposition or nodal analysis?

Solution:
Mesh analysis only requires 5 loops here. (1 point) Nodal analysis would require too many nodes. (1 point) Superposition is also not best because there are 5 different sources; it would be difficult to solve for each current loop. (1 point)

76. (4 points) A cylindrical wire with a current I passing through it and a volume V is suspended in a magnetic field with a flux density B. Express the magnetic force exerted on the wire in terms of π, r, B, I, and V.

Solution:
The volume of a cylinder is $V = \pi r^2 h$. The formula $h = \frac{V}{\pi r^2}$ can be drived from this.
$F = BI\frac{V}{\pi r^2}$

77. (2 points) Now replace that wire with an electron moving from west to east. If the magnetic field is pointing outwards, what direction will the electron be deflected?

Solution:
Using the left-hand rule, it's found that the magnetic force on the electron is pointing upwards.

78. (3 points) For the previous question, if the electron was moving outwards in the direction of the magnetic field, then how does this affect the magnetic force exerted on it?

Solution:
The electron would not be deflected as before because the electron is not moving perpendicular to the magnetic field.

79. (3 points) Briefly describe what reluctance is in the context of magnetic circuits.

Solution:

Reductance in magnetic circuits is the resistance against magnetic flux. (3 points) It's similar to how electric resistance in electric currents resists the flow of current.

80. (6 points) What is Faraday's Law of Induction? How is this applied in transformers and generators?

Solution:

Faraday's Law of Induction describes how magnetic fields react with electric circuits; a law of electromagnetism. It states that changes in magnetic flux over time will produce electromotive force (EMF). (2 points) Transformers use this concept using a core with high magnetic permeability as well as copper windings to change magnetic flux to step-up and step-down voltages. (2 points) Generators also use this concept by changing magnetic flux over time to generate EMF that can be used as electrical energy for different applications. (2 points)

81. (4 points) Let's go back to question 77. If the electron is moving at a velocity v and has a charge of q and the magnetic field has a flux density B, what is the magnetic force on the electron in terms of v, B and q? What law/formula is used to determine this magnetic force?

Solution:

The Lorentz force law is used to determine this magnetic force. (2 points)

$F = qvB$ (2 points)

82. (3 points) Pablo connects a battery in series with an LED. He finds that the LED burns out, but he isn't sure what is going on. Explain why the LED has burned out.

Solution:

The LED burned out because too much current was flowing through the LED and exceeded the maximum forward current range through the LED, making it burn out.

83. (3 points) Explain why it is important to put a multimeter on voltage mode when measuring voltage, current mode when measuring current, etc.

Solution:

Not putting a multimeter on the right mode can cause the probes used to measure to be hazardous and even explode when you're measuring.

84. (5 points) A student connects a battery, resistor and LED in series on a breadboard. The LED is not lighting up. Explain at least two possible reasons for why this could be happening. **Tiebreaker**

Solution:

Since the values of the battery or resistor are not specified, like in question 82, the current through the LED could have exceeded the maximum forward current range and caused the LED to blow up. Another reason it could not be lighting up is because it's in reverse bias, meaning that the voltage across the LED exceeds the voltage threshold, therefore it won't light up.