Circuit Lab C - Circuit Lab C Final - UT Invitational 2020 - Division C - 11-08-2020

This is the Division C Circuit Lab test. You will have 50 minutes to complete this test.

For any free response numerical question, any answer within 5% of our answer key will be accepted for full credit.

1. (1.00 pts) Which scientist first coined the term “electrodynamics”?

- A) Faraday
- B) Ohm
- C) Volta
- D) Ampere
- E) Kirchhoff
- F) Tesla

2. (1.00 pts) Which scientist proved that electricity could be generated chemically and not solely by living beings?

- A) Ampere
- B) Volta
- C) Kirchoff
- D) Ohm
- E) Tesla
- F) Faraday

3. (1.00 pts) Which scientist established the inverse square law of attraction and repulsion?

- A) Volta
- B) Kirchoff
- C) Ampere
- D) Coulomb
- E) Tesla
- F) Faraday

4. (1.00 pts) Which scientist invented the solenoid?

- A) Ampere
- B) Coulomb
- C) Tesla
- D) Faraday
- E) Kirchoff
- F) Ohm

5. (1.00 pts) Which scientist championed the idea of 'wireless electricity'?

- A) Faraday
- B) Ampere
- C) Ohm
- D) Tesla
- E) Kirchoff

F) Volta

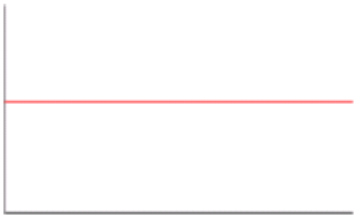
6. (2.00 pts) Under what conditions does static electricity build up more effectively?

A) On humid days
B) On dry days
C) On cold days
D) On hot days

7. (2.00 pts) You blow up a balloon and rub it against wool repeatedly (in one direction only). If you bring this balloon up to a wall, we can expect the balloon to:

A) Stick to the wall
B) Be repelled away from the wall
C) No effect - the rubbing does nothing
D) No effect - we should have rubbed in both directions to get an effect

8. (1.00 pts) Does this graph best represent AC or DC?



A) AC
B) DC

9. (2.00 pts) Which of the following primarily generates AC?

A) Battery
B) Oscilloscope
C) Synthesizer
D) Alternator

10. (1.00 pts) Which is considered more dangerous, DC or AC?

A) DC
B) AC

11. (4.00 pts) Explain at least two reasons for your selection to the previous question.

12. (2.00 pts) Nodal analysis is based on which of the following laws?

A) Kirchoff's Junction Law
B) Kirchoff's Voltage Law

C) Ohm's Law

D) Ampere's Law

13. (2.00 pts) Kirchoff's Junction Rule is **most directly** a restatement of which of the following?

A) Law of conservation of momentum

B) Law of conservation of charge

C) Law of conservation of energy

D) More than 1 of the above

E) All of the Above

14. (2.00 pts) TIEBREAKER #9: If the current over resistor A decreases by a factor of ½ and the value of resistor A stays constant, how much does the voltage over A change by?

A) increases by a factor of 2

B) decreases by a factor of ½

C) increases by a factor of 4

D) decreases by a factor of ¼

15. (2.00 pts) If we assume the total resistance of the circuit stays constant, how much will power change if the current increases by a factor of 2?

A) increases by a factor of 2

B) decreases by a factor of ½

C) increases by a factor of 4

D) decreases by a factor of ¼

16. (2.00 pts) A wheatstone bridge is best used for which of the following?

A) Measuring the capacitance of an unknown capacitor

B) Measuring the resistance of an unknown resistor

C) Measuring the voltage drop across a resistor

D) Measuring the amount of current over a given resistor

17. (2.00 pts) TIEBREAKER #8: A transistor can be thought of which of the following?

A) 2 separate diodes

B) 2 diodes with one of their regions joined together

C) 2 diodes working in parallel

D) 3 diodes linked together

The next three problems use the following setup:

A point charge Q1 has a magnitude of 1.4 * 10^-6 C, and another point charge Q2 8.0 centimeters away has a magnitude of -9.6 * 10^-7 C.

18. (3.00 pts) Determine the electrostatic force of Q1 acting on Q2.

A) 2.21 N

B) 1.35 N

C) 1.89 N

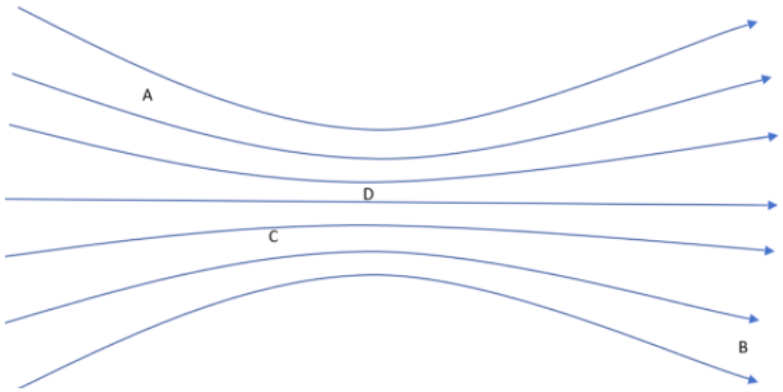
D) 4.56 N

19. (1.00 pts) Determine the electrostatic force of Q2 acting on Q1.

- A) 2.21 N
- B) 1.35 N
- C) 1.89 N
- D) 4.56 N

20. (2.00 pts) Explain whether the electrostatic force acting between Q1 and Q2 will be stronger or weaker than the force of gravity between them.

The next two problems use the following electric field:



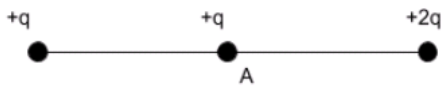
21. (2.00 pts) Rank the four points in decreasing order of the magnitude of force the electric field applies on them.

- A) A, B, C, D
- B) D, C, A, B
- C) C, A, B, D
- D) B, A, C, D

22. (2.00 pts) If a small negative charge is let go at point D, what direction will the charge move?

- A) Left
- B) Right
- C) Up
- D) Down
- E) Out of the page
- F) Does not move

23. (3.00 pts)
Three point charges are arranged in a line as follows:



The distance between neighboring point charges are all 9 cm. Determine the magnitude and direction of the resultant electrostatic force on point charge A if q = 1.0 * 10^-6 C.

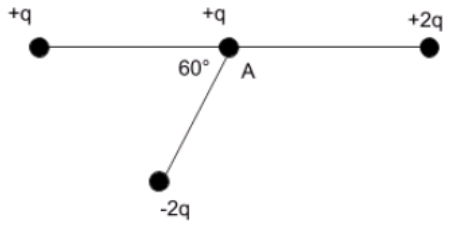
- A) 0.87 N, right

B) 0.87 N, left

C) 1.11 N, right

D) 1.11 N, left

24. (3.00 pts)
The four point charge setup is modified to this new arrangement:



The distance between the neighboring top three point charges are still 9cm, but the new fourth charge is 11cm away from point A. Determine the new magnitude and direction of the resultant electrostatic force on point charge A if q stays the same (1.0 * 10^-6 C).

A) 2.26 N, 34.8° north of east

B) 2.26 N, 34.8° south of west

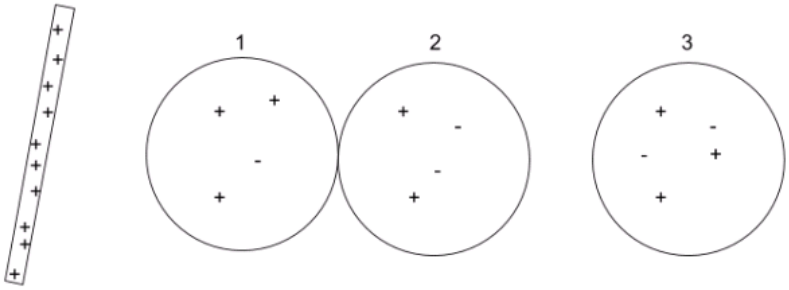
C) 1.13 N, 27.7° south of west

D) 1.13 N, 27.7° north of east

E) 4.21 N, 43.2° south of west

F) 4.21 N, 43.2° north of east

25. (2.00 pts)
TIEBREAKER #7: Imagine we have a conducting rod and three conducting sphere in the following setup. A plus sign denotes one point charge of magnitude +1 C, and a minus sign denotes one point charge of magnitude -1 C. Sphere 1 and 2 are initially touching.



We bring the conducting rod close to spheres 1 and 2, and separate the two spheres. We then remove the rod from the system. Then, we touch sphere 2 with sphere 3. We disconnect those two and touch sphere 2 with sphere 1 again. What is the resulting net charge of sphere 1?

A) +1 C

B) +2 C

C) 0 C

D) -2 C

26. (3.00 pts) Two long parallel wires both have a current of 2 A running through them. What is the magnitude of the magnetic force between the wires per meter of length?

A) 1.0e-6 N/m

B) 1.2e-6 N/m

C) 1.4e-6 N/m

D) 1.6e-6 N/m

E) 1.8e-6 N/m

27. (3.00 pts) If an electron is moving at 5.20e7 m/s through a .009 T magnetic field applying a force perpendicular to the direction of travel, what is the radius of the path?

A) 1.2120 m

B) .0329 m

C) .4061 m

D) .0086 m

E) .4834 m

28. (2.00 pts) If we imagine a basic ideal DC motor with a stall torque of M and a no-load speed of N, under which conditions will the motor be outputting the most power?

A) 1M, 0N

B) 0M, 1N

C) .75M, .25N

D) .25M, .75N

E) .5M, .5N

29. (3.00 pts)
A DC motor has a field flux of 40 mWb and a current of 50 A flowing through its armature. The relation between electric and mechanical power can be described by $\frac{\varphi ZN}{60}$ x $\frac{P}{A}$ x I_a = T x $\frac{2\pi N}{60}$ The variables Z, P, and A are motor-specific characteristics. For the purposes of this problem, treat the expression $\frac{ZP}{A}$ as a constant equal to 4. Use this information to determine the armature torque of the DC motor.

A) 8.00 N/m

B) .0795 N/m

C) 31.8 N/m

D) 2.00 N/m

E) 1.27 N/m

30. (2.00 pts) What type of 3-way switch was prohibited in the United States by the National Electrical Code in 1923?

A) Traveler

B) Carter

C) Alternative

D) California 3-way

31. (2.00 pts)
Your 3-way light switch is broken. One of the switches (call it switch A) now works as a normal switch, but only if the other switch (switch B) is in the down position. If switch B is in the up position, switch A is no longer able to turn the light on. What could be wrong with the switch?

A) The common wire is broken

B) Switch B is stuck

C) One of the traveler wires is broken

D) The light bulb requires too much power

E) None of the above

32. (2.00 pts) As long as there is an appreciable depletion region in a silicon PN junction, _____

A) current can flow in two directions

B) current flow is enhanced in one direction

C) there are many holes from the P-type material along the junction

D) current flow is blocked

E) None of the above

33. (2.00 pts) TIEBREAKER #6: Suppose you wanted to create a 3x3 array of white LEDs. Which of the following would be the smallest battery that could still power this array?

A) A 4 V battery
B) A 12 V battery
C) A 16 V battery
D) A 36 V battery

34. (2.00 pts) In general, how is the polarity of a surface-mounted diode indicated?

A) With a line indicating the cathode
B) With a line indicating the anode
C) One of the legs will be marked to represent the cathode
D) One of the legs will be marked to represent the cathode

35. (2.00 pts) Alice connects her LED to the circuit and it lights up a brilliant red. Bob tries to do the same, but his LED does not light up at all. What could have gone wrong?

A) Bob reversed the terminals
B) Bob's LED is blue and requires a higher forward voltage
C) Bob supplied too much current to his LED
D) Bob's LED is too cold
E) A, B
F) A, B, C

36. (3.00 pts) A transformer has a turn's ratio of 1 : 3.9 and a secondary voltage of 1250 volts, what would be the primary voltage?

A) 320.5 V
B) 324.4 V
C) 1250 V
D) 4875 V
E) 4878.9 V

37. (2.00 pts) Which of the following gates is considered the "universal logic gate"?

A) AND
B) NAND
C) XOR
D) OR

38. (3.00 pts)
The implication operator (=>) is an operator commonly used in mathematics. Its truth table is given below. Given this, determine the equivalent boolean expression to this operator.

p	q	p => q
T	T	T
T	F	F
F	T	T
F	F	T

A) (p OR q) NAND (p AND q)

B) p OR NOT q

C) NOT p OR NOT q

D) None of the above

39. (2.00 pts) Suppose we had a charging RC circuit. At t=0, the capacitor in the circuit acts most similarly to which of the following devices?

A) Diode

B) Resistor

C) Wire

D) Air (Open Circuit)

40. (2.00 pts) Suppose we had a charging RC circuit. At t=(infinity), the capacitor in the circuit acts similarly to which of the following devices?

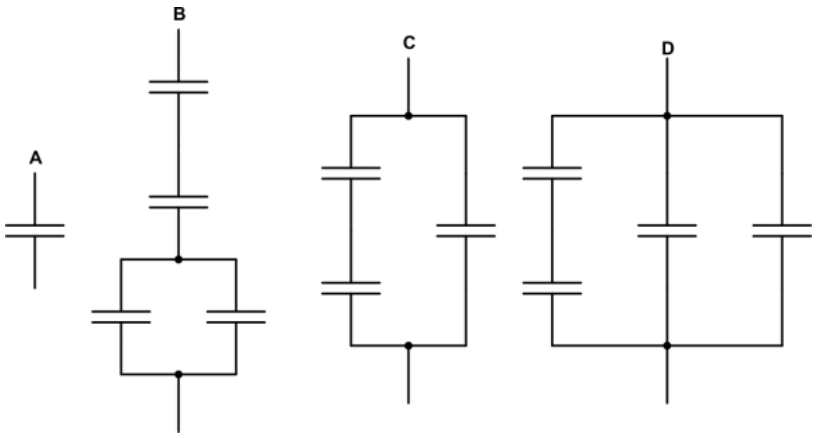
A) Diode

B) Resistor

C) Wire

D) Air (Open Circuit)

41. (2.00 pts) TIEBREAKER #5: Rank each system in decreasing order of total capacitance, assuming all capacitors have the same capacitance.



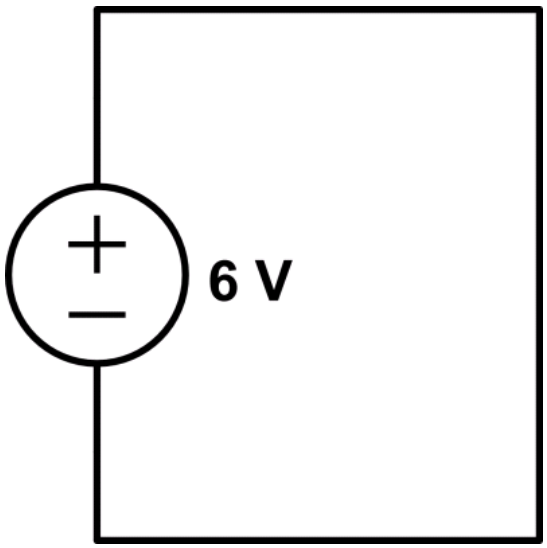
A) A, B, C, D

B) B, A, C, D

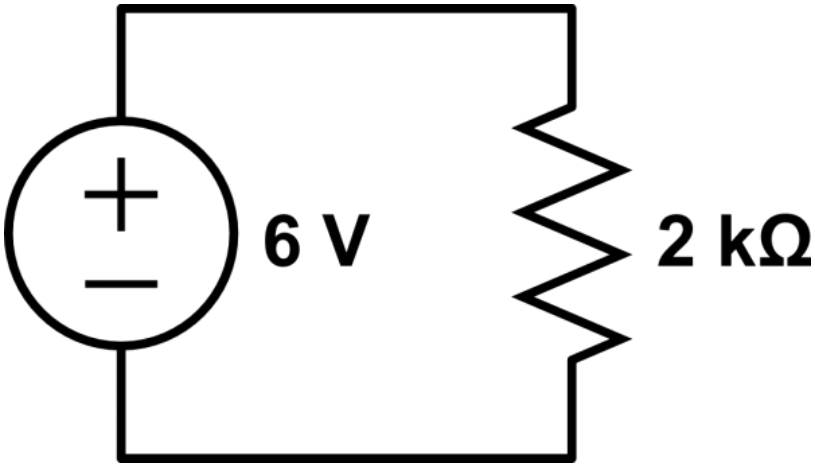
C) D, C, A, B

D) C, D, B, A

42. (3.00 pts) Explain the problem with the following circuit setup:

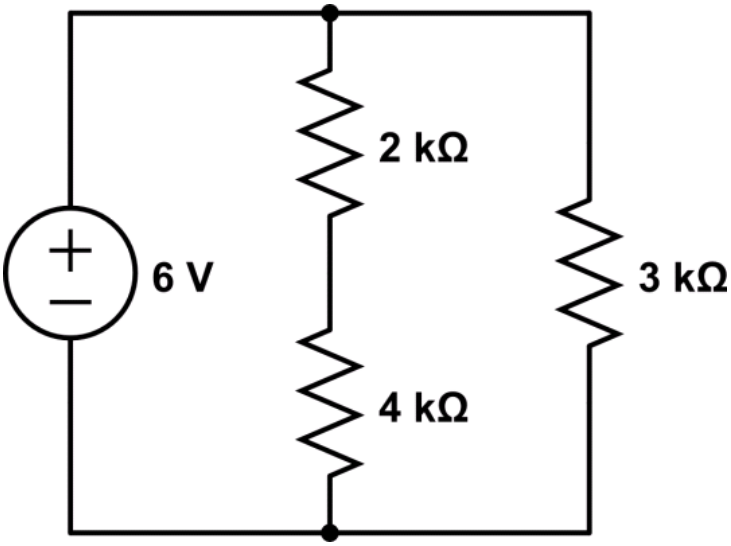


43. (2.00 pts) What is the current through this circuit?



- A) 333.3 A
- B) 0.003 A
- C) 12 A
- D) 12000 A

The next three problems use this circuit:



44. (2.00 pts) What is the overall current through this system?

- A) 3 mA
- B) 2 mA
- C) 1 mA
- D) 1.5 mA

45. (2.00 pts) What is the current through the 4 kiloohm resistor?

- A) 4 mA
- B) 2 mA

C) 1 mA

D) 3 mA

46. (2.00 pts) What is the voltage across the 2 kiloohm resistor?

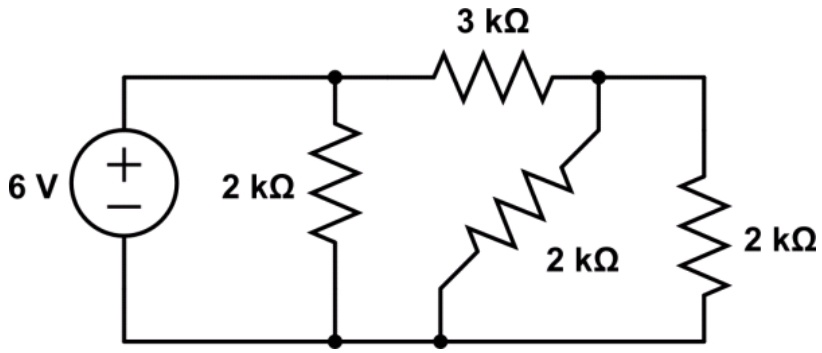
A) 4 V

B) 2 V

C) 6 V

D) 1 V

47. (3.00 pts) What is the overall current through this system?



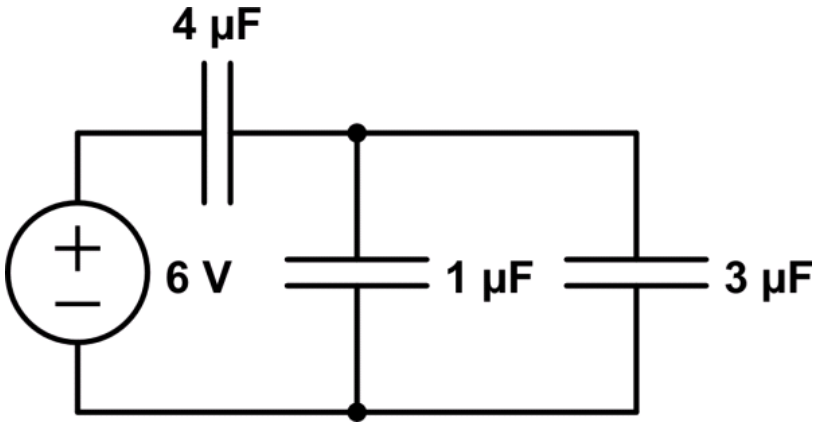
A) 4.5 mA

B) 3 mA

C) 2 mA

D) 6 mA

The next five problems use this circuit:



48. (3.00 pts) What is the overall charge of this circuit on the capacitors?

A) 36 microcoulombs

B) 12 microcoulombs

C) 6 microcoulombs

D) 3 microcoulombs

49. (2.00 pts) What is the voltage across the 1 microfarad capacitor?

A) 2 V

B) 3 V

C) 6 V

D) 1 V

50. (3.00 pts) What is the charge on the 3 microfarad capacitor?

A) 3 microcoulombs
B) 1 microcoulomb
C) 6 microcoulombs
D) 9 microcoulombs

51. (3.00 pts) We put a dielectric with dielectric constant 5 between the two plates of the 3 microfarad capacitor. What is the new overall total charge of the system?

A) 16.5 microcoulombs
B) 24.4 microcoulombs
C) 19.2 microcoulombs
D) 26.5 microcoulombs

52. (3.00 pts)
We move the plates of the 4 microfarad capacitor to twice their previous distance (the dielectric is still in the 3 microfarad capacitor). What is the new overall charge of the system?

A) 4.32 microcoulombs
B) 5.65 microcoulombs
C) 6.54 microcoulombs
D) 7.23 microcoulombs

53. (1.00 pts) True/False: The Norton Equivalent Resistance is equal to the Thevenin Equivalent Resistance

True False

54. (1.00 pts) True/False: One can find the Thevenin and Norton equivalents of an operational amplifier

True False

55. (1.00 pts) True or False: Lightning is caused by static electricity.

True False

56. (1.00 pts) True or False: Direct current requires a conductor to flow through.

True False

57. (1.00 pts) True or False: All AC follows a sine wave pattern.

True False

For each of the following five problems, determine if they primarily use AC or DC.

58. (1.00 pts) Electronic Circuits

A) DC

B) AC

59. (1.00 pts) Home Outlets

A) DC
B) AC

60. (1.00 pts) Long distance uses

A) DC
B) AC

61. (1.00 pts) Automobile Batteries

A) DC
B) AC

62. (1.00 pts) Phones

A) DC
B) AC

63. (3.00 pts) TIEBREAKER #4: Which of the following are equal to the Boolean equation: $\overline{(AB)(\overline{A+B})}$

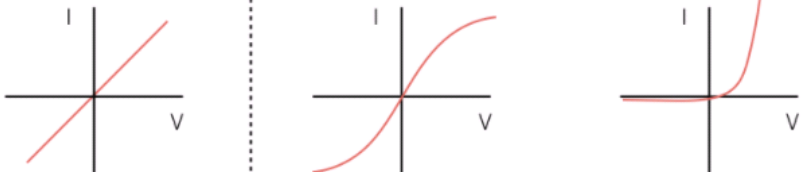
(Mark **ALL** correct answers)
A) 0
B) 1
C) AB
D) A(B')
E) B' + B
F) A(A')

64. (4.00 pts) Which of the following are ways to make an electromagnet stronger?

(Mark **ALL** correct answers)
A) Use a heavier battery
B) Increase the number of coils
C) Increase the flow of current through the coils
D) Change the composition of the core to soft iron

65. (4.00 pts)
The skin effect is a phenomenon in which high-frequency AC current is forced to flow closer to the surface of a wire opposed to the center. The skin effect is caused by ____ currents and can be mitigated by using a ____ wire.

66. (6.00 pts)



Label the above graphs from left to right. Use the letters.

A. diode B. copper C. filament lamp

67. (5.00 pts)
A wire is looped 10 times with a radius of 20 cm is placed in a 2 T magnetic field. If the wire has a resistance of 10 Ohms and a voltage of 1 V across it, what is the torque on the loops? Assume the loops are perpendicular to the magnetic field. (Answer to three decimals)

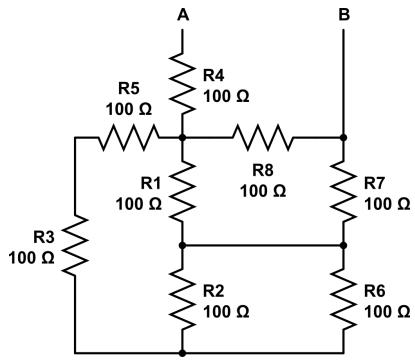
68. (5.00 pts)
A thin metal tube of length 1 m is placed in a vacuum devoid of any electric field with a cylindrical conducting rod of length 1 m placed inside. If the radius of the rod is 10 cm and the radius of the tube is 10.5 cm, what is the capacitance of the system? (Answer to two decimals)

69. (5.00 pts)
You charge your Tesla Model 3 for 8 hours via a standard 120V/15A outlet and decide to go on a trip. If you average 60 mph and average 13kW power consumption, how far are you able to travel in miles? (Answer to two decimal places, units not necessary)

70. (4.00 pts)
If we compare a 2000 V power transmission line to a 25000 V power transmission line, how many times more efficient is the 25000V power transmission line given the same power? (Answer to two decimal places)

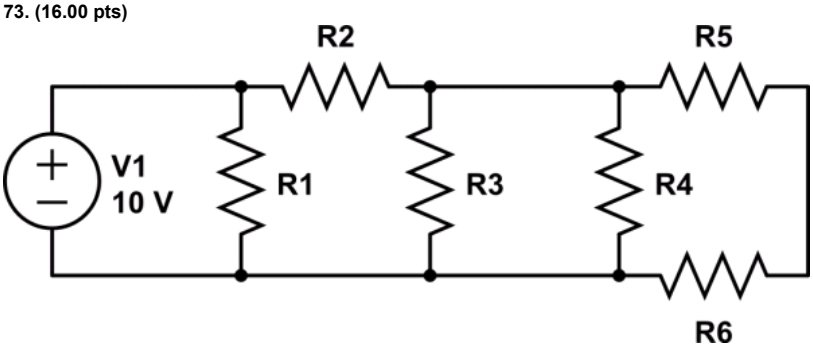
71. (4.00 pts)
A battery has an internal resistance of 0.24 Ω and an EMF of 3.00 V. When connected in series to R_L, the terminal voltage is 2.91 V. What is the ohm value of R_L? (Answer to two decimals, units not necessary)

72. (6.00 pts)



What is the equivalent resistance between points A and B? (Answer to the nearest whole number, units not necessary)

73. (16.00 pts)



Suppose the had the following diagram. R1 = 10 Ω, R2 = 12Ω, R3 = 2Ω, R4 = 6Ω, R5=R6=15Ω. Determine the following rounded to 2 decimal places (ex. 0.11 V, 15.13 V)

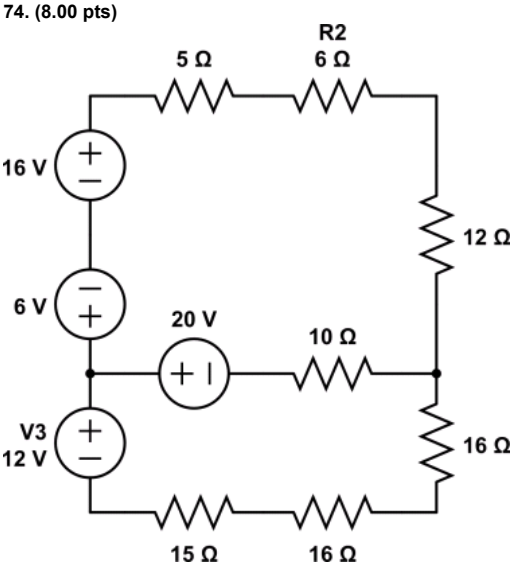
Note: DO NOT ROUND until the very end. Units are not required for any of the following questions.

a) R_{eq}, the equivalent resistance in Ohms

b) Determine the magnitude of the voltage drop across R2 in Volts

c) Determine the magnitude of the voltage drop across R5 in Volts

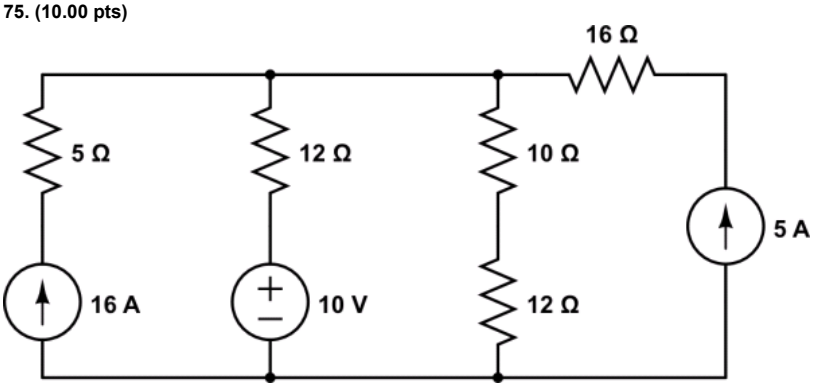
74. (8.00 pts)



Given the following diagram, determine the magnitude of the voltage drop in Volts across the 10Ω resistor using only Kirchhoff's Laws. Please include units and round your answer to 2 decimal places (ex. 10.01 V).

Note: DO NOT ROUND until the very end.

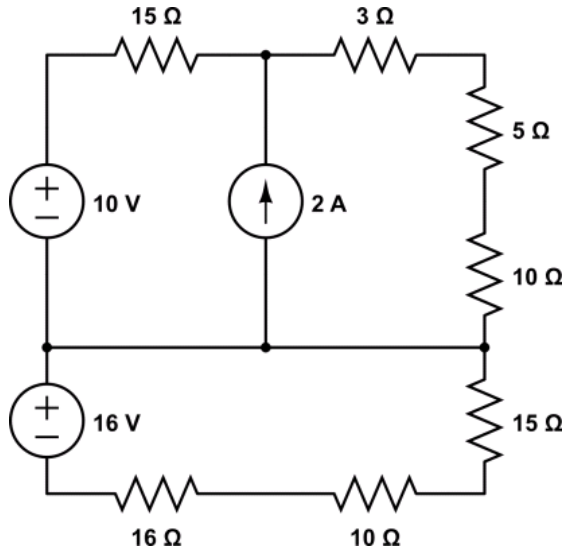
75. (10.00 pts)



TIEBREAKER #3: Using the superposition principle, find the voltage drop across the 10Ω resistor in Volts. Include units in your final answer and round to two decimal places. (ex. 16.35 V)

Note: DO NOT ROUND until the very end.

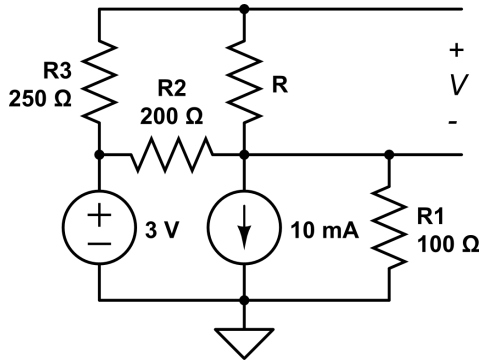
76. (10.00 pts)



Using Mesh Analysis, determine the voltage drop across R1 in Volts. Round to 2 decimal places and include units in your final answer (ex. 1.31 V)

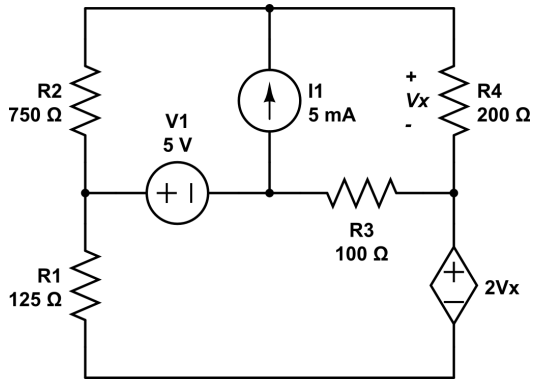
Note: DO NOT ROUND until the very end.

77. (12.00 pts)



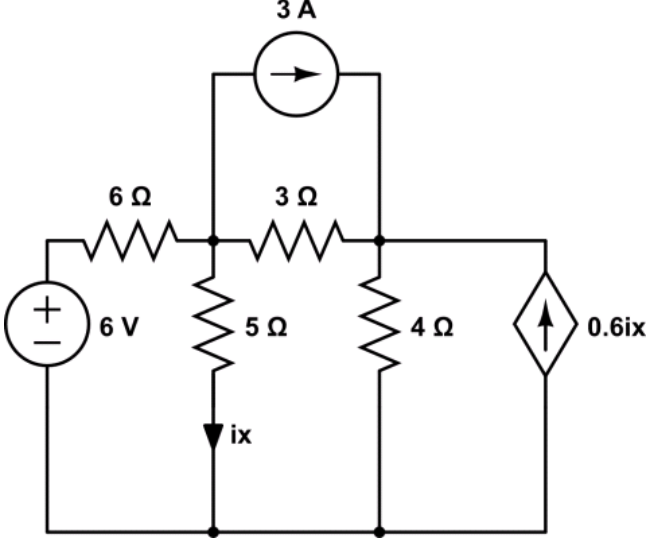
Given that V = 1.8V, what is the resistance of resistor R? (Answer to the nearest whole number, units not necessary)

78. (10.00 pts)



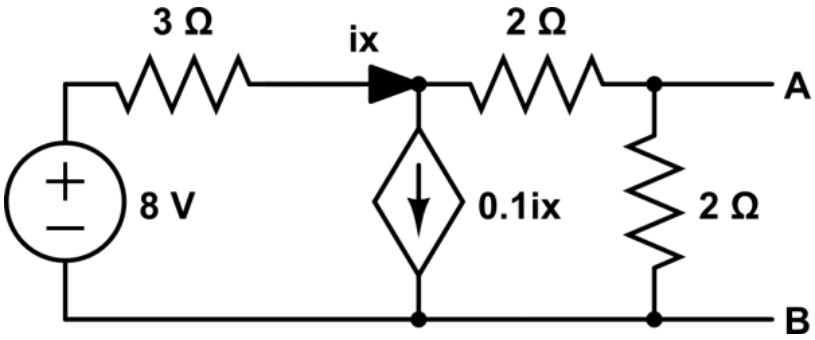
Determine the voltage across the 5 mA source. (Answer to three decimal places)

79. (8.00 pts)



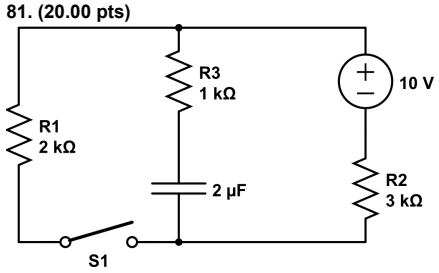
TIEBREAKER #2: Compute the power in watts over the 5Ω resistor. (Answer to three decimals)

80. (10.00 pts)



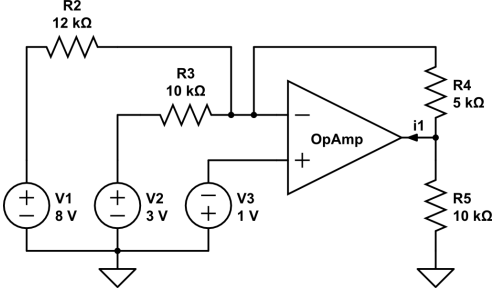
Find the Thevenin equivalent circuit. Answer V_{TH} in volts in the first blank, and R_{TH} in ohms in the second. (Answer to two decimal places, units not necessary)

81. (20.00 pts)



a) If the 2μF capacitor has a dielectric medium of air and plates with a surface area of 0.1 m2, what is the separation of the two plates in nm? (Answer to the nearest whole number)
b) At time t=0ms, the voltage source in the above circuit is turned on. At t=10ms, what is the current going through R2? (Answer to three decimals)
c) If S1 is closed at t=10ms, what is the current through R1 immediately after S1 is closed. (Answer to two decimals)
d) After a long period of time, what is the voltage across the capacitor?

82. (12.00 pts)

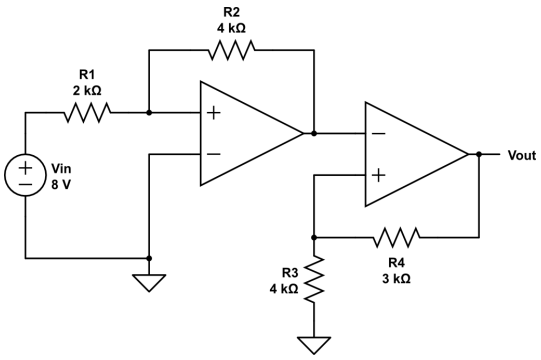


TIEBREAKER #1

a) What is the voltage output of the above op-amp? (Answer to two decimals)

b) What is the value of i1? (Answer to three decimals)

83. (12.00 pts)



Determine Vout.

Congratulations on completing the exam!