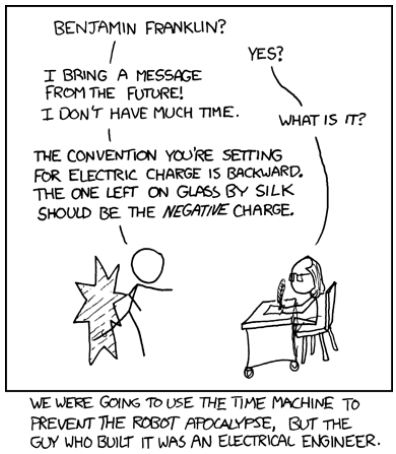
Welcome to Camas C-Invite 2020-21 Circuit (Lab)!



Sure, we could stop dictators and pandemics, but we could also make the signs on every damn diagram make sense. (Source: xkcd)

Before you start, here are some things to note:

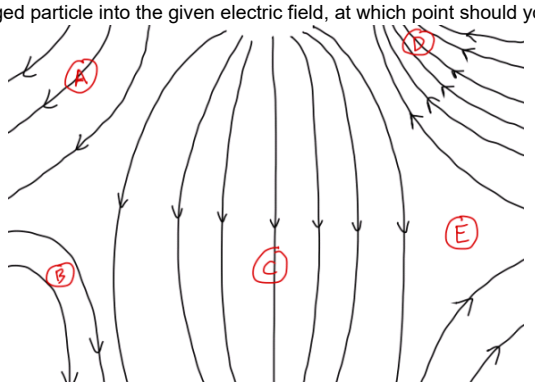
- I recommend that you write your answers for multiple-choice and fill-in-the-blank questions on a piece of paper, so in case we have technical difficulties, you can quickly re-input y answers.
- I picked 10 tiebreakers at random, but in the extremely rare case that those 10 questions are not enough to break a tie, the 1st question will become the next tiebreaker, then the question, and so on.
- Some questions are related to each other, so if you split the work, make sure to communicate with your partner to avoid solving the same problem twice.

Finally, here is a tip on how to be successful on this test:

Try to get them all right :)

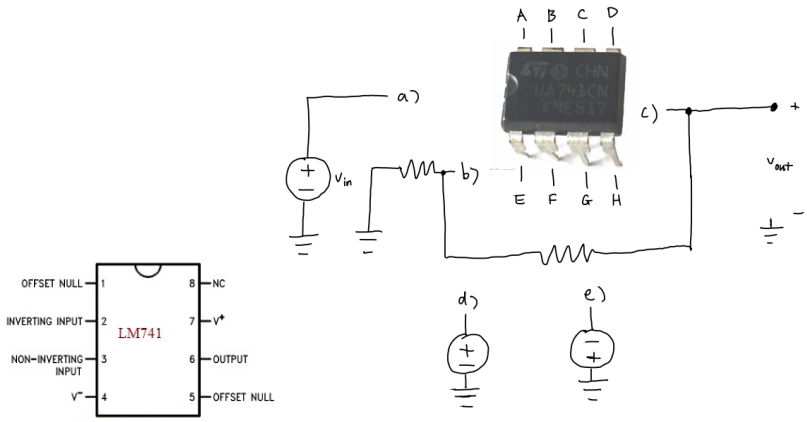
1. (1.00 pts)

If you want to place a +2.71 nC charged particle into the given electric field, at which point should you place for maximum acceleration?



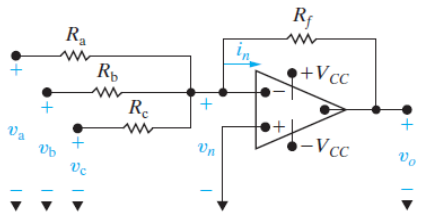
- A) A
- B) B
- C) C
- D) D
- E) E

2. (1.00 pts)
Indicate which leg (A-H) of the given operational amplifier should be connected to wire (a), (c), and (d) to create a noninverting-amplifier circuit. The pinout diagram of the operational amplifier is given below. Fill in the blank with the letter A-H corresponding to the leg you want to connect to. Left blank is for (a). Middle blank is for (c). Right blanl is for (d).



G	C	B

3. (2.00 pts) Refer to the diagram below. $R_a = R_b = R_c = 2\ \Omega$. $R_f = 8\ \Omega$. $v_a = 3$ V. $v_b = 5$ V. $v_c = 1$ V. $+V_{CC} = 15$ V. $-V_{CC} = -15$ V. Calculate the value of v_o. (TB#10)



- (●) A) -15 V.
- ( ) B) -36 V.
- ( ) C) 9 V.
- ( ) D) 36 V.

4. (1.00 pts) When measuring current across a resistor, you should connect an analog ammeter in _____

- ( ) A) Parallel with the resistor because if connected in series, the ammeter will add too much resistance to the circuit, resulting in inaccurate measurement.
- ( ) B) Parallel with the resistor because connecting in series will result in short-circuiting the ammeter.
- ( ) C) Series with the resistor because if connected in parallel, there will be no current running through the d'Arsonval meter movement's coil.
- (●) D) Series with the resistor because if connected in parallel, the ammeter will become a short circuit, allowing electrons to bypass the resistor.

5. (1.00 pts) Kirchhoff's laws are incredibly useful in circuit analysis. Kirchhoff developed those laws based on the work of whom?

- ( ) A) Maxwell

- [x] B) Ohm
- [ ] C) Tesla
- [ ] D) Volta
- [ ] E) Ampere
- [ ] F) Kirchhon

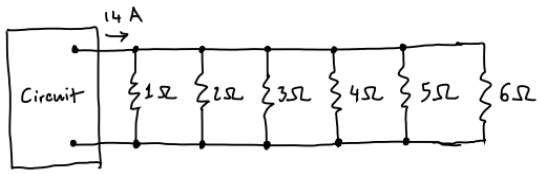
6. (1.00 pts) How did Coulomb come up with his law?

- [ ] A) He copied Newton's Law of Universal Gravitation but made sure to change it a little bit.
- [ ] B) The law came to him when an apple fell on his head while he was taking a nap.
- [x] C) He studied the repulsion and attraction forces of charged particles using a torsion balance.
- [ ] D) He placed a negative charged particle in the middle of a box and shot an electron at the particle to measure the velocity of the particle after being pushed by the electrostatic force.

7. (1.00 pts) Which electrical component below can only dissipate power from the circuit?

- [x] A) Resistor
- [ ] B) Battery
- [ ] C) Capacitor
- [ ] D) Inductor

8. (1.00 pts) What is the magnitude of the current going through the 4 Ω resistor?



- [ ] A) 3.50 A
- [ ] B) 2.33 A
- [ ] C) 5.71 A
- [x] D) 1.43 A

9. (1.00 pts)

You want to be able to turn the bathroom's light on or off from both the inside or the outside of the bathroom. The inside switch is connected to the power source. You decided to implement a 3-way light switch circuit for the task. However, you notice that the outside switch can only turn the light on or off when the inside switch is switched up. What could be the possible cause?

- A) You accidentally switched the wires for the traveler terminals for the inside switch.
- B) You mistakenly connected one of the traveler wires to the common terminal instead of the wire from the power source for the inside switch.
- C) You accidentally switched the wires for the traveler terminals for the outside switch.
- D) You mistakenly connected one of the traveler wires to the common terminal instead of the wire from the power source for the outside switch.

10. (1.00 pts)
For the step response of an RC circuit, if we graph voltage on the y-axis and time on the x-axis, which of the following graphs have the most similar shape to our graph?

- A) $y = e^{-t}$
- B) $y = 1 - e^{-t}$
- C) $y = e^{t}$
- D) $y = 1 - e^{t}$

11. (1.00 pts)
A 5-band resistor has the color brown for the 1st band, green for the 2nd band, gray for the 3rd band, red for the 4th band, and brown for the 5th band. If you apply a 9V battery across the resistor, what is the current going through the resistor?

- A) 0.00057 mA
- B) 0.0057 mA
- C) 0.057 mA
- D) 0.57 mA

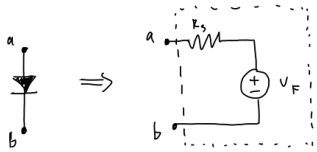
12. (1.00 pts) How much power is dissipated from a 2400 Ω resistor connecting to a 12V battery?

- A) 28800 W
- B) 0.005 W
- C) 0.06 W
- D) 1450 W

13. (1.00 pts) How do you differentiate between the circuit symbol of an npn-transistor and of a pnp-transistor?

- (●) A) The arrow points outward for npn-transistor and inward for pnp-transistor.
- ( ) B) The arrow points outward for pnp-transistor and inward for npn-transistor.
- ( ) C) The arrow is horizontal for pnp-transistor and vertical for npn-transistor.
- ( ) D) The arrow is vertical for npn-transistor and horizontal for pnp-transistor.
- ( ) E) You can't differentiate them from looking at the circuit symbol.

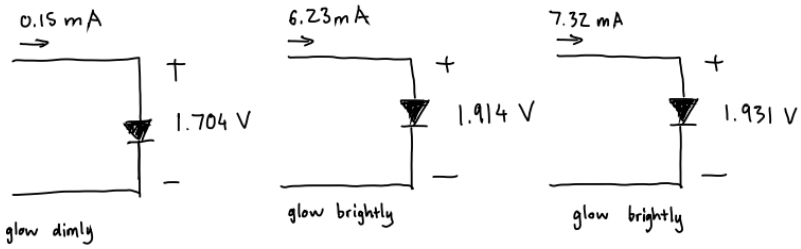
14. (1.00 pts) To create Thévenin equivalent model for an LED, we have an internal resistance R_s and a turn-on voltage V_F as shown in the diagram below.



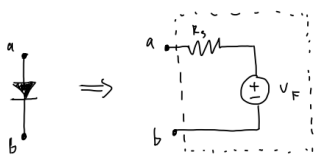
Why do we need to include a resistor in our Thévenin equivalent model?

- ( ) A) We need the resistor to help prevent the LED from burning out.
- ( ) B) There is an actual resistor connected to the LED internally.
- (●) C) We need to take in account the power dissipation behavior of the LED.
- ( ) D) We need to reduce the amount of current going through the actual LED.

15. (2.00 pts)
You just bought a single LED from the store. You don't know why you bought it, so now you want to come up with a Thévenin equivalent model for it. You did some measurements and obtained the following data.



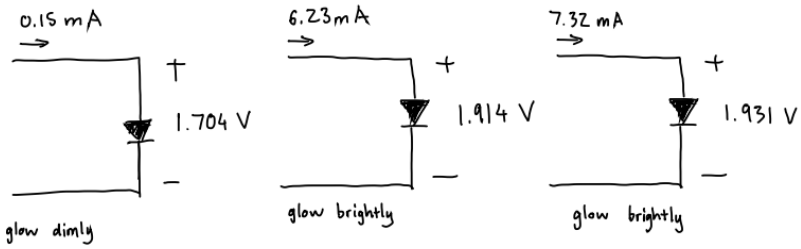
Use the following model.



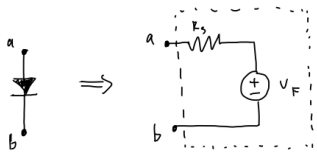
Find R_s in Ω. (TB#8)

- A) 15 Ω
- B) 10 Ω
- C) 13 Ω
- D) 20 Ω
- E) None of the above.

16. (2.00 pts)
You just bought a single LED from the store. You don't know why you bought it, so now you want to come up with a Thévenin equivalent model for it. You did some measurements and obtained the following data.



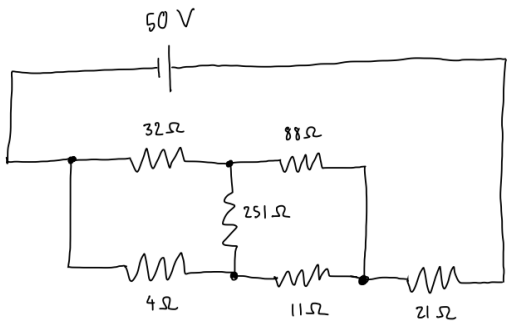
Use the following model.



Find V_F in V. (TB#9)

- A) 2.2 V
- B) 1.8 V
- C) 1.5 V
- D) 0.9 V
- E) None of the above.

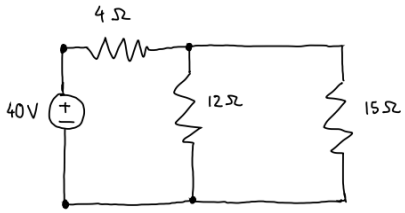
17. (3.00 pts) Find the power generated by the battery in the following circuit.



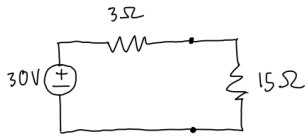
- A) 6.14 W
- B) 8.76 W
- C) 1.46 W

- (●) D) 72.8 W
- ( ) E) None of the above

18. (3.00 pts) Find the percentage of the source power delivered to the 15 Ω resistor. The Thévenin equivalent circuit is given for you.

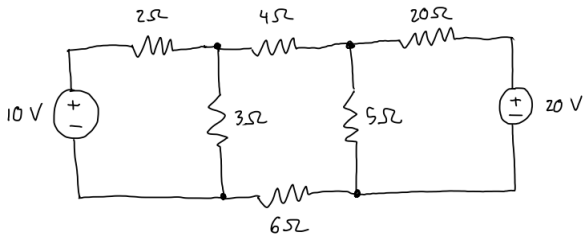


Thévenin equivalent :



- ( ) A) 83 %
- ( ) B) 48 %
- ( ) C) 63 %
- (●) D) 28 %
- ( ) E) None of the above

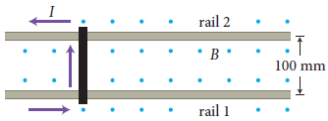
19. (3.00 pts) What is the power dissipated by the 2 Ω resistor in Watt?



- ( ) A) 2.0 W
- ( ) B) 3.1 W
- ( ) C) 1.8 W
- (●) D) 2.4 W
- ( ) E) None of the above.

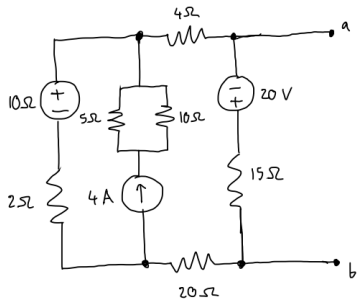
20. (2.00 pts)

In a certain TV show, a character nicknamed “Railgun” applies a force of 2,546,750 N to fire her railgun. What value of current I in the picture below would allow the railgun in the picture to apply the same amount of force as the character? The dot indicates the direction of the magnetic field. Assume the magnetic field is 100 T. Round to the nearest whole number.



- (●) A) 254,675 A
- ( ) B) 329,201 A
- ( ) C) 249,018 A
- ( ) D) 10,032 A
- ( ) E) None of the above.

21. (3.00 pts) 20. (3 pts) Find the value of the Thévenin resistance with respect to terminals a and b.



- (●) A) 30/7 Ω
- ( ) B) 5.22 Ω
- ( ) C) 23/8 Ω
- ( ) D) 9.41 Ω
- ( ) E) None of the above.

22. (1.00 pts) The NAND and NOR gates are known as universal gates. What does that mean? Answer in one short, simple sentence.

Expected Answer: You can make other types of gate with them.

23. (3.00 pts) Write the minimized Boolean expression for Y. (TB#7)

A	B	C	D	Y
0	0	0	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

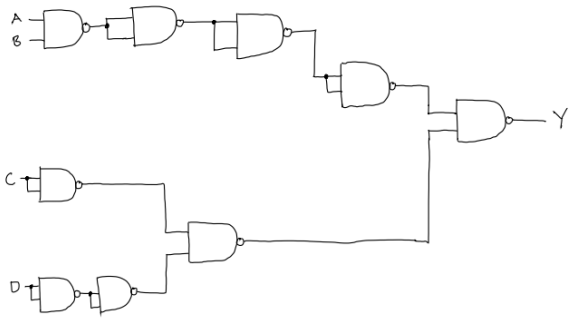
- A) Y = AC + A'BD + BC' + B'D'
- B) Y = A'C + A'BD + AB'C' + B'D'
- C) Y = A'BC + B'C' + BD'
- D) Y = AB' + A'BD + AB'C'
- E) None of the above.

24. (3.00 pts) Minimize the following Boolean expression.

$$\overline{A}BC\overline{D} + A\overline{F}G + (\overline{B+F} + \overline{C+F})G + D\overline{F}G$$

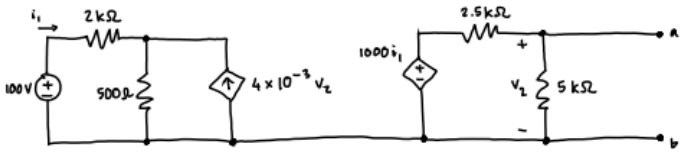
- A) A'BCD' + EF'G
- B) ABCD + EFG
- C) A'BDG' + CEF
- D) A'BD' + CEF'G
- E) None of the above.

25. (2.00 pts) Write the minimized Boolean expression for Y.



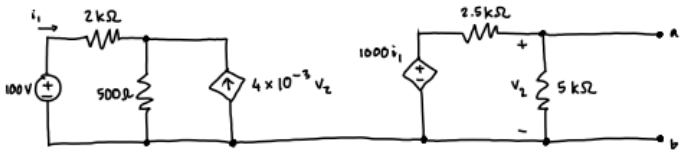
- A) AB' + CD'
- B) (AB)' + (CD)'
- C) (AB)' + CD'
- D) AB + CD
- E) None of the above.

26. (2.00 pts) Find the value of i_1 in the given circuit.



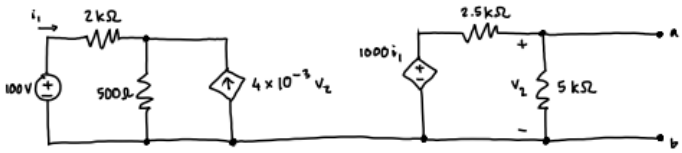
- A) 3/46 A
- B) 6/29 A
- C) 32/7 A
- D) 3/115 A
- E) None of the above.

27. (2.00 pts) Find the value of v_2 in the given circuit.



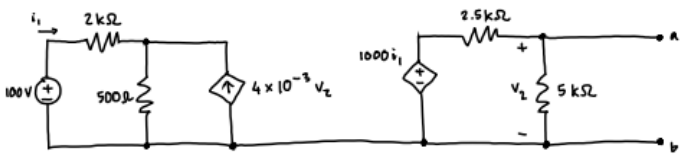
- A) 98/3 V
- B) 400/23 V
- C) 431/34 V
- D) 33/5 V
- E) None of the above.

28. (1.00 pts) Find the magnitude of the Norton equivalent current in the given circuit. (TB#1)



- A) 0.239 A
- B) 0.0104 A
- C) 0.00135 A
- D) 0.0218 A
- E) None of the above.

29. (1.00 pts) Find the value of the Thévenin equivalent resistance of the given circuit. (TB#2)



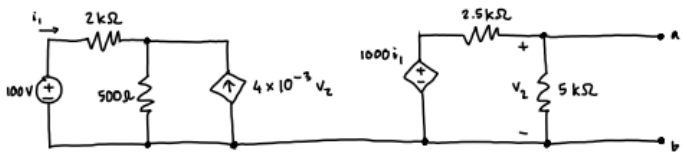
- A) 4782/5 Ω
- B) 2000/7 Ω

C) 5098/12 Ω

D) 5000/3 Ω

E) None of the above.

30. (1.00 pts)
You would like the draw the Norton equivalent circuit of the given circuit. Assuming positive value for the current, which terminal should the arrow of the current source point toward?

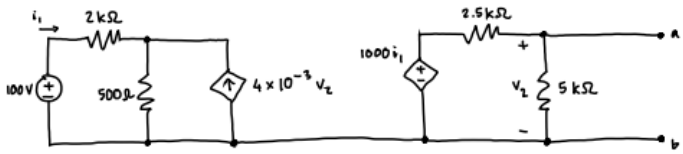


A) a

B) b

C) Norton equivalent circuit does not have a current source.

31. (1.00 pts) You would like the draw the Norton equivalent circuit of the given circuit. Should the current source be connected in parallel or in series with the resistor?



A) in parallel.

B) in series.

C) Norton equivalent circuit does not have a current source.

32. (2.00 pts) Consider the following sinusoidal voltage: $v(t) = 35cos(350t + 54^\circ)$ V. Find the V_{rms} and the period. Pick one choice for V_{rms} and one choice for the period.

(Mark **ALL** correct answers)

A) V_rms = 35 V

B) V_rms = 17.5 V

C) V_rms = 24.7 V

D) P = 2.860 ms

E) P = 17.95 ms

F) P = 0.45 ms

33. (1.00 pts) Consider the following sinusoidal current: $i(t) = 56cos(27000t - 20^\circ)$ A, where t is in milliseconds. What is the frequency in Hz?

A) 27000 Hz

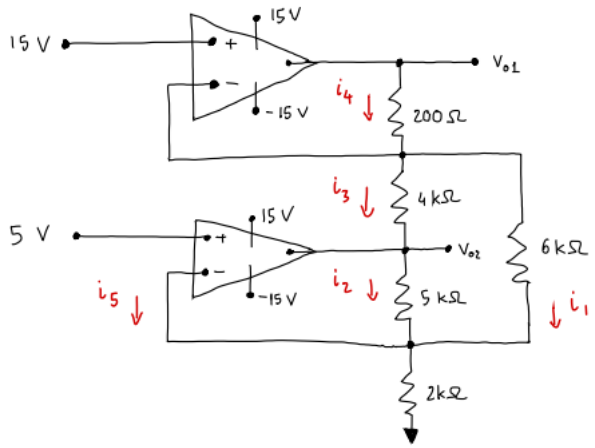
B) 4297 Hz

C) 25 Hz

D) 4.3 Hz

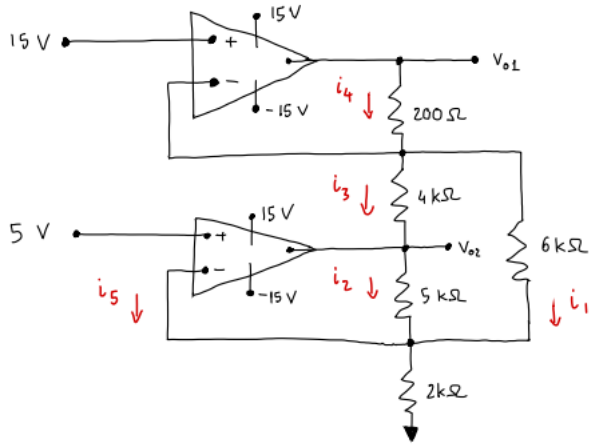
E) None of the above.

34. (1.00 pts) Find the magnitude of i_1 in the given circuit.



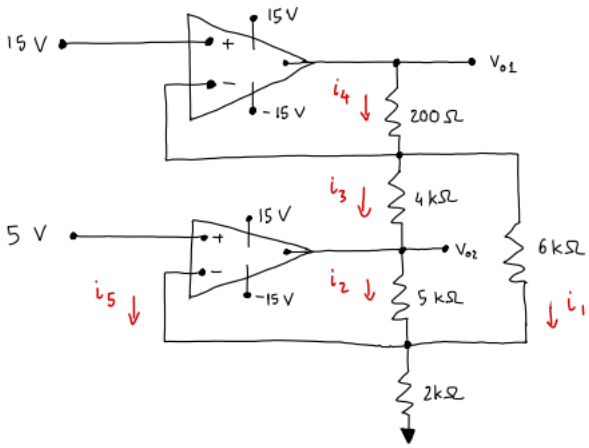
- A) 1 mA
- B) 2.5 mA
- C) 1.42 mA
- D) 0.63 mA
- E) None of the above.

35. (1.00 pts) Find the magnitude of i_2 in the given circuit.



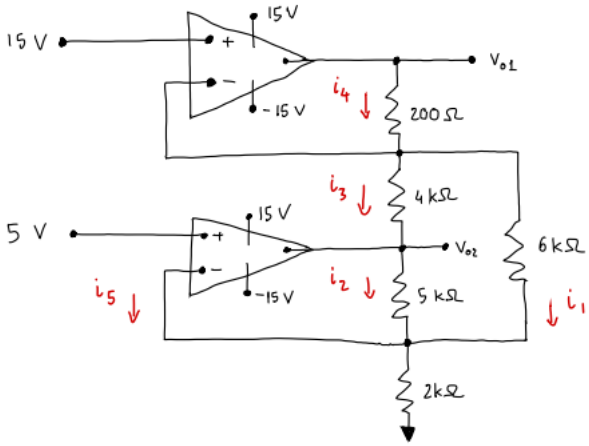
- A) 2.0 mA
- B) 1.5 mA
- C) 1.2 mA
- D) 0.8 mA
- E) None of the above.

36. (1.00 pts) Find the magnitude of i_3 in the given circuit.



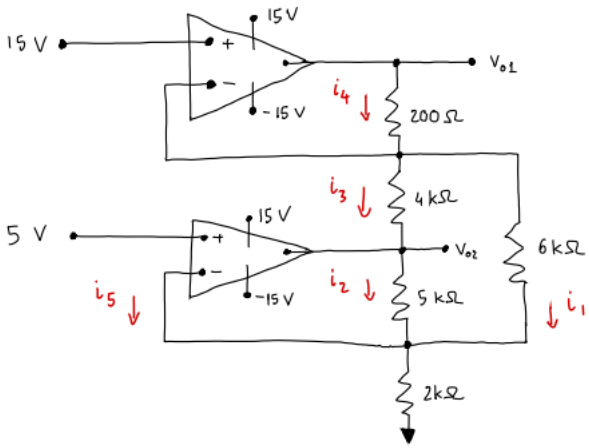
- A) 1.250 mA
- B) 1.150 mA
- C) 0.775 mA
- D) 0.625 mA
- E) None of the above.

37. (1.00 pts) Find the magnitude of i_4 in the given circuit.



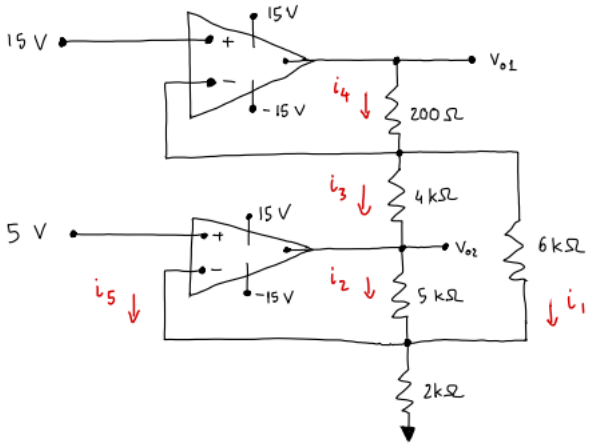
- A) 3.250 mA
- B) 2.150 mA
- C) 1.625 mA
- D) 1.225 mA
- E) None of the above.

38. (1.00 pts) Find the magnitude of i_5 in the given circuit.



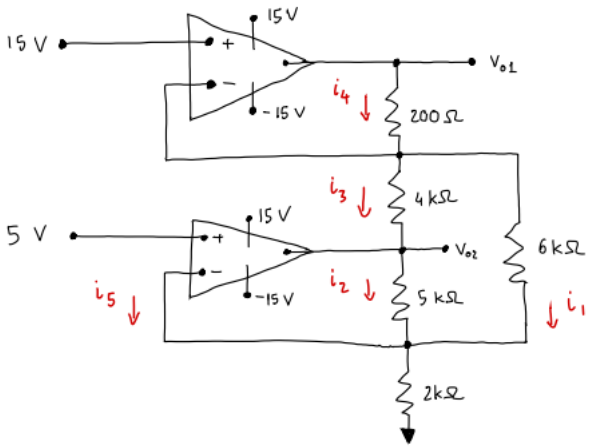
- A) 0.25 mA
- B) 0.70 mA
- C) 1.30 mA
- D) 2.50 mA
- E) None of the above.

39. (1.00 pts) Find the magnitude of v_{o1} in the given circuit. (TB#4)



- A) 15.3 V
- B) 12.5 V
- C) 10.2 V
- D) 8.6 V
- E) None of the above.

40. (1.00 pts) Find the magnitude of v_{o2} in the given circuit. (TB#3)



- A) 15.3 V
- B) 12.5 V
- C) 10.2 V
- D) 8.6 V
- E) None of the above.

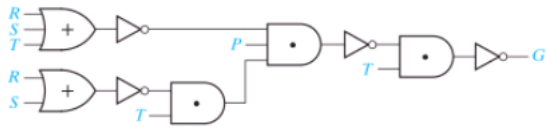
41. (1.00 pts)
For an unknown RC circuit, you know nothing about the components. However, you have the natural response graph of the circuit, and you know that the tangent line at t = 0 for the natural response curve is $v(t) = 12 - 600t$ where v(t) is in V and t is in second. Find the time constant of the circuit.

- A) 0.0200
- B) 0.0325
- C) 0.0400
- D) 0.0600
- E) None of the above.

42. (5.00 pts)
Our students built an electrical truss that is infinitely long, for whatever reason. He wants to measure the resistance of the ladder between point A and B. Assume each member are a of resistance 1.00 Ω, what is the value he wound measure?
(You can assume each node has infinitely low resistance, and member resistance AC=CE=... = BD= BC = ... = 1.00 Ω.

Expected Answer: 1.62 Ohm $(1+\sqrt{5})/2$

43. (5.00 pts) Simplify the following circuit and find the expression for G.
(Use A' as inverse of A, AB as A AND B, A+B = A OR B)



Expected Answer: T'

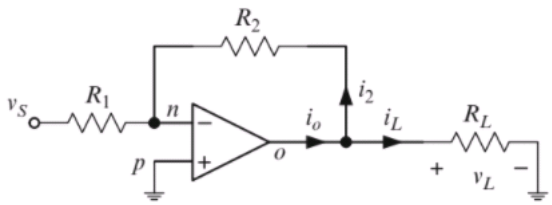
44. (6.00 pts) What is the number of the logic gates needed to implement the following logic?
How many total gate input signals?
How many logic levels in this implementation?

$$Z_1 = [(A + B)C + DE(F + G)]H$$

6 | 13 | 4

45. (5.00 pts) What is the maximum power dissipated by the power amplifier in the follow circuit? Give your answer in mW. Show work to get full points.

Vcc= 25.0 V, $R_L = 100.\Omega$, $R_1 = 10.0k\Omega$, $R_2 = 1000.k\Omega$. Consider this as an ideal amplifier.



Expected Answer: Load resistance of op amp is R_load = R_L || R_2, so about 1 kOhm, or 990 Ohm. P_amp = P_input - Pout. The maximum DC output is when Vcc = 2 x V_load, so Max power is Vcc^2/(4 R_Load) = 158 mW

46. (6.00 pts)
Using the given measurements, find the Thévenin equivalent circuit for the potato. An enlarged picture of the connected resistor is provided. Assume the resistor has nominal value. The pictures got cut off, but the alligator clippers are connected directly to the multimeter. (TB#5)

For the left blank, type V_th = (your answer) V. For the right blank, type R_th = (your answer) ohm. Round your answers to the nearest hundredth place. Keep all values positive. This question will be manually graded.


DIGITAL MULTIMETER
AUTO
DC
-.571
V
IEC61010-1 2000 Counts/Autorange
FUNC
HOLD
MAX
OFF
OFF
crenova
MS8233D
10A
600V CAT III
COM


DIGITAL MULTIMETER
AUTO
DC
-38.7
µA
IEC61010-1 2000 Counts/Autorange
FUNC
HOLD
MAX
OFF
OFF
crenova
MS8233D
10A
600V CAT III
COM

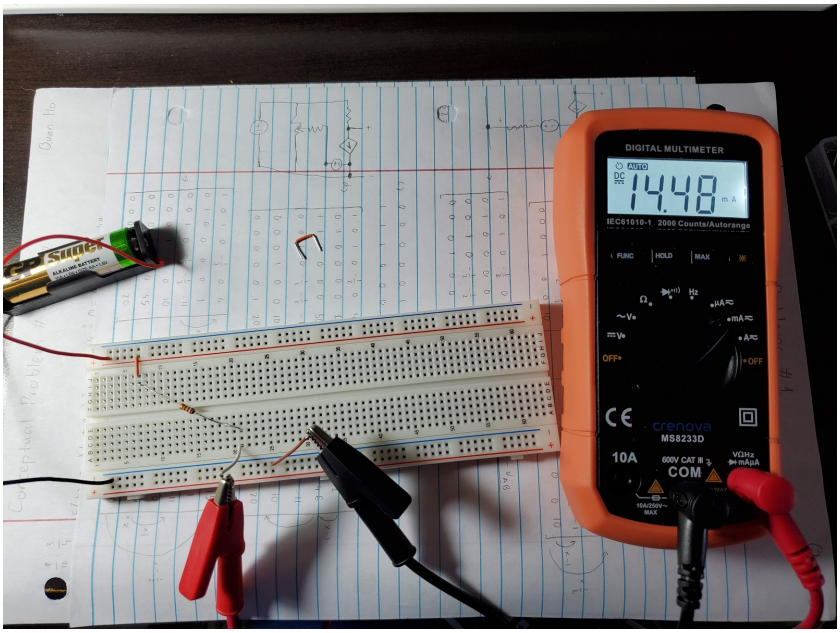
V_th = 0.57 V

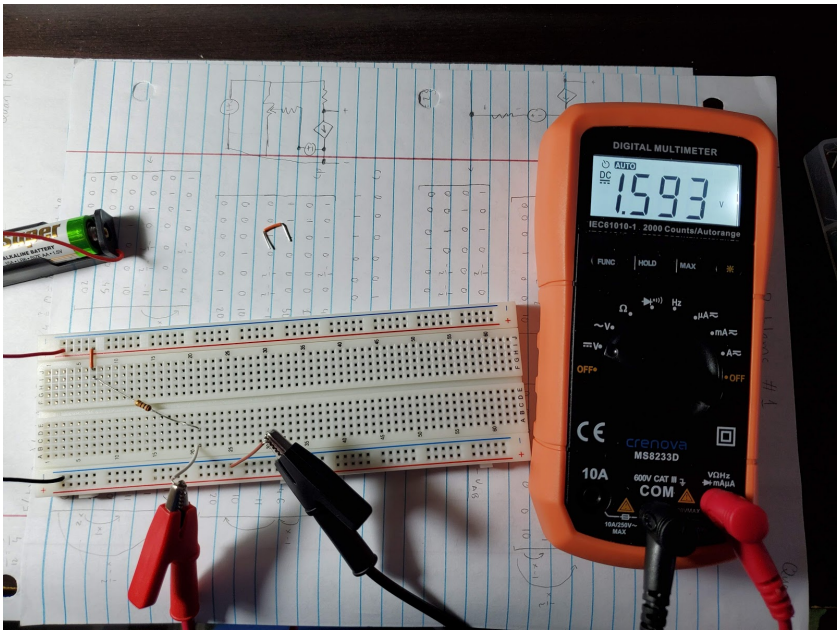
R_th = 14654.52 ohm

47. (6.00 pts)

Using the given measurements, find the Thévenin equivalent circuit for the connected battery. An enlarged picture of the connected resistor is provided. Assume the resistor has nominal value. The pictures got cut off, but the alligator clippers are connected directly to the multimeter. The shown battery is also connected directly to the breadboard with the red and black wires. Don't pay attention to the papers, just some matrix algebra and random circuit diagrams as background. (TB#6)

For the left blank, type V_th = (your answer) V. For the right blank, type R_th = (your answer) ohm. Round your answers to the nearest hundredth place. Keep all values positive. This question will be manually graded.





V_th = 1.59 V

R_th = 10.01 ohm

48. (2.00 pts)

From the previous two questions, in 1-2 sentences, explain the reason why the actual battery is the better "battery" than the potato. Give a circuit-related explanation.

Example of zero-point answers:

"The potato is too big." (We do not judge potato based on its appearance.)

"Carrying two nails around is inconvenient." (Yes, I agree. But not the correct answer for this question.)

"Someone might eat the potato while it is in use." (That's your problem for carrying only one potato around.)

Expected Answer: The potato has a significantly higher internal resistance (1pt) which reduces the power being delivered to the load (1pt).

Congratulations on making it to the final section! Time for a question about an RLC circuit connected to an AC source!

I'm just joking, that question would be illegal for this event anyway.