Circuit Lab KEY

Scarsdale High School 2019-2020

-You have 50 minutes to complete this test
-You have up to 10 minutes to complete the lab portion of the test, taken out of your 50 min
-You may have a 3 ring binder and a calculator of any type
-Show all work, for each calculation question, the answer is 1pt, the initial equation is 1pt, and the units are 1pt. All other points come from the work
-Report each answer to a reasonable amount of sig figs. Credit only taken off if it is grossly unreasonable.
-It is unlikely that you will finish the test, pick the parts you are best at
-Use conventional flow for all circuits

-Any questions to wolfcukier@gmail.com

History	/20
Theory	/30
Fill in the Blank	/20
Calculations	/50
Diagraming	/30
Lab	/50
Total	/200

Part 1: History (20 pts)

Each of the Following Statements describes a scientist listed in the rules. Place a (**O**) for Ohm, a (**V**) for Volta, a (**F**) for Faraday, a (**T**) for Tesla, (**K**) for Kirchhoff, (**C**) for Coulomb, and a (**A**) for Ampere

1. Namesake for the unit of EMF	*V*
2. Calculated the speed of an electrical signal in a resistanless wire is equal to the speed of light	*K*
3. Namesake for unit of Magnetic Flux Density	*T*
4. Namesake for unit of Resistance	*O*
5. Explained the laws of attraction between charges and poles	*C*
6. Published *The Galvanic Circuit Investigated Mathematically*	*O*
7. Demonstrated that a changing magnetic field produces an electric field	*F*
8. Invented the dynamo	*F*
9. Showed two parallel current-carrying wires attract or repel each other	*A*
10. Invented the induction motor	*T*
11. Inventor of the Radio	*T*
12. Isolated and ignited methane using an electric spark	*V*
13. Invented the Solenoid	*A*
14. Invented the Homopolar Motor	*F*
15. Discovered the Law of Capacitance	*V*
16. Stated that current is inversely proportional to resistance	*O*
17. Believed that attraction and repulsion was due to fluids	*C*
18. Discovered Diamagnetism	*F*
19. Invented the spectroscope along with Bunsen	*K*
20. Stated the sum of currents into a node is the same as the sum of currents out of a node	*K*

Part 2: Theory(30 pts)

21. What is the greatest hazard of static electricity? What are some precautions taken to avoid this? (6)

Igniting Flammable Gases (3) - Other lesser hazards (1)

Reducing the risk of ignition from static discharge is achieved by bonding, earthing, or substitution. Bonding is the process of connecting two or more conductive objects together by means of a conductor. Earthing involves connecting one or more conductive objects to the ground. Substitution involves replacing conductive materials with non-conductive ones. (Any one - 3, other reasonable if incorrect 1st part - 2)

22. Describe 2 ways to create a charged object. (6)

Answers may vary 3 pts each . Induction - bring uncharged object in near charged object and break it in 2 / break connection to ground. And Conductance - bring uncharged object in contact with uncharged object.

23. Which is safer, AC or DC, to be electrocuted with at the same voltage? Why? (6)

DC (2 pts)
--Any of below 4 pts--
AC voltage is just average and the peak voltage is higher
AC voltage does not require a closed circuit
AC can create capacitance with the ground

24. What is a Faraday Cage? What is an application of one (6 pts)

*A **Faraday cage** or **Faraday shield** is an enclosure used to block <u>electromagnetic fields</u>. A Faraday shield may be formed by a continuous covering of <u>conductive material</u>, or in the case of a Faraday cage, by a mesh of such materials. (3)*
Uses may Vary - include protecting people from discharges or sensitive electronics (3)

25. What would one use for transmission of electricity over large distances, AC or DC?

AC (3) because transformers allow for high voltage transfer that minimizes power loss (3)

Part 3: **Fill in the Blank (20 pts)**

26. Kirchhoff's voltage law is based on conservation of _energy_ (2)

27. Kirchhoff's current law is based on conservation of _charge_ (2)

28. In a PN Junction, negative charges are transferred by electrons and positively charges are transferred by _holes_ (2)

29. LED stands for _Light Emitting Diode_ (2)

30. At t=0 a capacitor is at 0 V, after one time constant, the capacitor is at _63_% of the battery's voltage (2)

31. In reality, electrons flow from the _negative_ terminal to the _positive_ terminal of a battery (2)

32. A logic gate that in combination with itself is able to create the AND, NOT, and OR gate is called a _Universal Gate_ (2)

33. An ideal Op-Amp has _infinite_ Open-Loop Gain (2)

34. The inverse of conductivity is _resistivity_ (2)

35. SPDT stands for _Single Pole Double Throw_ (2)

Part 4: Calculations (55 pts)

36. Point charge A has a charge of +1C, point charge B, located 2m to the right of point charge A has a charge of -3C. What is the force of A on B. Be sure to indicate directions. (5)

F=(kQ_1 Q_2)/d^2 [1 pt]
*F=(9e9 * 1 * -3)/(2^2) [1 pt]*
*F = 6.75 * 10^-9 [1 pt] N [1 pt], Force Acting to Left [1 pt]*

37. Given the Circuit below and that R1 = 150 Ohms, R2 = 650 Ohms, R3 = 400 Ohms, and R4 = 150 Ohms, complete the table. Remember to show work, there should be at least 3 different equations used. (17 pts)
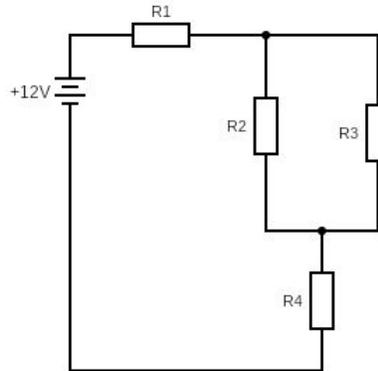
	R	V	I	P
1	150 Ohms	3.3 V	0.022 A	0.0726 W
2	650 Ohms	5.4 V	0.0084 A	0.0449 W
3	400 Ohms		0.014 A	0.0729 W
4	150 Ohms	3.3 V		0.0726 W
Total	547.6 Ohms	12 Volts		0.263 W

Each Number is 1 pt, units for Current and Power are 1 pt each (missing units on the others is -1 on first offense per unit), stating a form of Ohm's Law(R=V/I) is 1 pts, Stating a form of power equation(P=VI=I^2R=V^2/R) is 1 pts, Proper equations for circuit simplification RT = R1 + 1/(1/R2 + 1/R3) + R3(1)

38.a. What is the capacitance of a parallel plate capacitor if the plates have an area length of 9 m^2 and are separated by 10^-9 m? (4)

C = epsilon * A/d [1 pt], C = 1/(9e9 *4pi) * (9/10e-9) [1 pt], 0.080 [1 pt] F [1 pt]

38.b. How much charge does it take to charge the capacitor in 38.a from 0V to 12.57V? (4)

Q=CV [1 pt], Q = 0.80 * 12.57 [1 pt], Q=1 [1 pt] J [1 pt] (Accept answers consistent with incorrect answers of 38.a)

38.c How much energy does it take to charge the capacitor in 38.a from 0V to 12.57V? (4)

E = ½*QV = ½ * C * V^2 = Q^2/2C (1pt for any form), E = ½*Q*12.57 [1 pt] E=6.29 [1 pt] J [1 pt]

39.a. At t=0, the switch is closed. What is the time constant of the following circuit? (4)
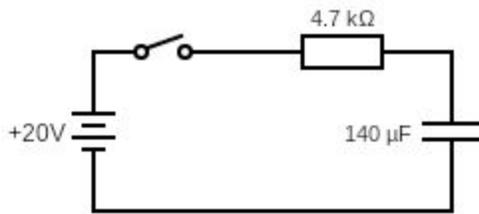
tau = RC [1 pt], tau = 4.7 * 10^3 * 140 * 10^-6 [1 pt], tau = .66 [1 pt] s [1 pt]
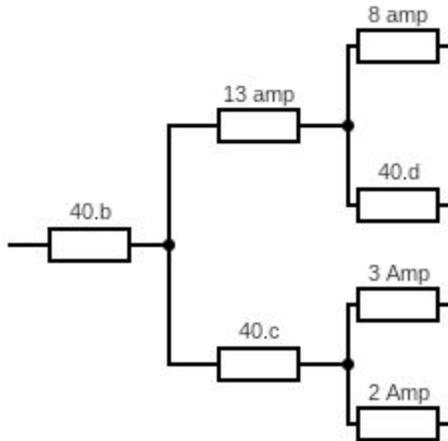
39.b. What is the voltage across the capacitor at t = 1.5s (4)

Vc = Vb * (1-(1/e^(t/tau))) [1pt], Vc = 20* (1-(1/e^(1/.66))) = 15.6 [1 pt] V[1 pt]

40.a. State Kirchhoff's Current Law (1)

I_in = I_out

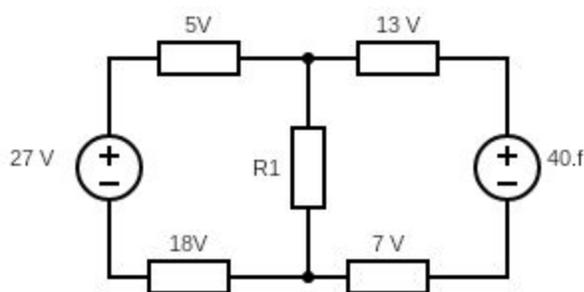40.b. - 40.d. Calculate the following. No work necessary. (3)

40.b = 18 A, 40.c = 5 A, 40.d = 5 A

40.e. State Kirchhoff's Voltage Law (1)
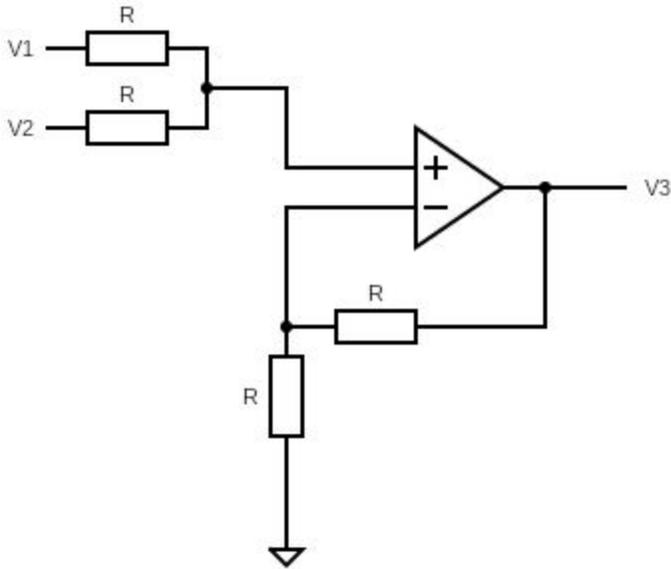
The sum of voltages around a loop is equal to 0

40.f Calculate the following. No work necessary. (3)

24 [2pts] V [1pt]

Part 5 - Diagraming (40 pts)

41.a. Draw a diagram using a single op-amp such that the output voltage, V3, is equal to the sum of 2 input voltages, V1+V2. (6)

Op amp (triangle) present [1pt]
V1 and V2 lead into one of the terminals [.5pt] and into the (+) terminal [.5 pt]
V3 is rom the output side [1 pt]
One terminal connected to ground [.5 pt], (-) terminal [.5 pt]
One terminal connected to output [.5 pt], (-) terminal [.5 pt]
Resistor in Correct location [1 pts]

41.b. What is the name of 41.a? (1)
Non-inverting summing [0.5 pt] Amplifier/Op-Amp [0.5 pt]

42. Draw the diagrams for the logic gates corresponding to the following truth tables and name them. Partial credit if diagram uses more than one logic gate. (6)

A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

A	B	Q
0	0	1
0	1	1
1	0	0
1	1	0

A	B	Q
0	0	1
0	1	0
1	0	0
1	1	1

AND

A
B — Q

XOR

A
B — Q

NAND

A
B — Q

OR

A
B — Q

NOT

A — Q

XNOR

A
B — Q

.5 pts for name, .5 pts for diagram iff only one gate

43. Draw a diagram with a lamp and two switches such that changing the state of either switch changes the state of the lamp regardless of the state of the other switch. (5)
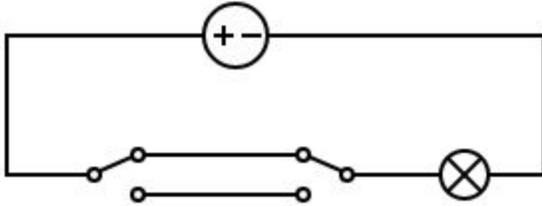
1 pt for voltage source / battery
*1 pt for lamp*
1 pt for 2 switches
1 pt for correct type of switch
1 pt for actually would work

44. Draw a labeled diagram of a PN Junction (not circuit symbols but one that could be used to demonstrate the functionality) (6)

1pt for Overall look, 1 pt for N region, 1 pt for P region, 1 pt for depletion layer, 1 pt for labeling electrons, 1 pt for labeling hole

45. Draw the magnetic field between 2 bar magnets of equal strength such that the north ends are facing each other (6)
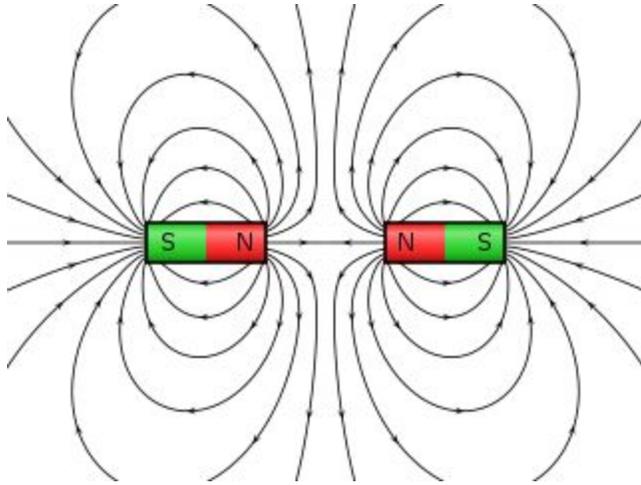
1 pt for symmetry
1 pt for N to S
1 pt for no intersections
1 pt for demonstrating interaction of field
1 pt for extra lines drawn into /out of each side that don't connect back on page
1 pt for the connections back

Part 6: Lab (50 pts)

Using 5 LEDs, a resistor, a battery, and jumper cables, construct a circuit such that:

46.a. In one polarization of the battery, LED 1 and LED 2 are off and LED3 and LED 4 are on (10)

46.b. In the other polarization of the battery, LED 3 and LED 4 are off and LED 1 and LED 2 are on (10)

47. Regardless of the polarization, LED 5 remains on (10)

48. You ensure that none of the LEDs burn out (5)

49. Draw a circuit diagram of what you created(10)

To score the circuit diagram, score it out of 5 points by determining if the diagram matches the points earned with the physical part. Award partial credit if you see fit.
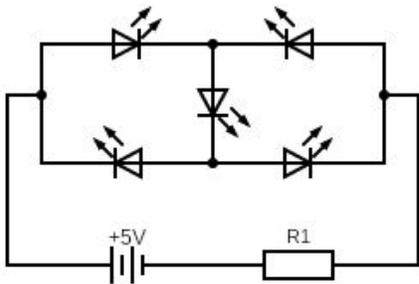
50. State the color code and resistance of the resistor (5)

2 pts for proper color code, 2pts for either correct resistance or for one consistent with the color code. 1 pt for all correct

Task	46.a	46.b	47	48
ES initial				