PHY 1120
Exam 2
7/9/2020

Name Alex Yeoh Table #_____

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Total _____ / 100 pts

Useful Information:		
$n = 10^{-9}$	$k = 9.0 \times 10^{9}\ N \cdot m^2/C^2$	$\epsilon_o = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$
$p = 10^{-12}$	$c = 3.0 \times 10^{8}\ m/s$	$G = 6.67 \times 10^{-11}\ N \cdot m^2/kg^2$
	$\mu_o = 4\pi \times 10^{-7}\ T \cdot m/A$	

Clearly check or fill in the box in front of the answer(s) you are selecting. Each question will have only one **best** answer. Some questions may require multiple selections to answer the question completely. **Briefly explain your answer** (2 pts each)

1) A battery with an *EMF* = 13.8V is connected to a 72 Ω resistor. If the current through the resistor is 0.183 A, what is the internal resistance of the battery?

$Emf = IR + Ir = I(R+r)$

$\frac{EMF}{I} = R + r$

$\frac{EMF}{I} - R = r = \frac{13.8}{0.183} - 72 = 3.41\Omega$

The internal resistance is 3.41Ω because see calculation

2) For a basic circuit connected to a 12 V battery, if the current increases what must have happened to the resistance?

- [x] The resistance went down.
- [ ] The resistance didn't change.
- [ ] The resistance went up.
- [ ] More information is required.

$V = IR$

Since the battery doesn't change, V stays the same I and R are inversely proportional in this case, so if I increases, R must go down.

3) Three resistors, 37 Ω, 41 Ω, 25 Ω, are connected in parallel then connected to a 9.0 V battery. What is the total current from the battery?

- [ ] 0.087 A
- [x] 0.82 A
- [ ] 1.21 A
- [ ] 11.4 A

$R_{Total} = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}} = \frac{1}{\frac{1}{37}+\frac{1}{41}+\frac{1}{25}} = 10.94\Omega$

$V = IR$

$I = \frac{V}{R} = \frac{9}{10.94} = 0.82A$

4) 4.00 C of charge passes through a length of wire in exactly 4 minutes. What is the current in that wire.

- [x] 0.0167 A
- [ ] 0.0667 A
- [ ] 1.0000 A
- [ ] 60.000 A

$I = \frac{Q}{t} = \frac{4}{(4 \mid 60)} = \frac{4}{240} = 0.016\ A$

5) A 4-band resistor has the following colors; Violet, Orange, Red, Red. What is the resistance of this resistor?

- [ ] $7.3 \times 10^2\ \Omega$ +/- 2%
- [ ] $7.32 \times 10^2\ \Omega$
- [x] $7.3 \times 10^3\ \Omega$ +/- 2%
- [ ] $7.32 \times 10^3\ \Omega$

7 3 $\cdot 10^2 \pm 2\%$

$73 \cdot 10^2 \pm 2\% = 7.3 \cdot 10^3 \pm 2\%$

6) In a given circuit, if I double the voltage what happens to the power delivered by the battery?

- ☐ The power is halved.
- ☐ The power doesn't change.
- ☒ The power is doubled.
- ☐ The power is quadrupled.

$P = IV$

if V doubles, P also doubles

7) Three parallel capacitors, 137 pF, 77 pF, 109 pF, are connected to a battery. What is the total capacitance of this system of capacitors?

- ☐ 33.9 pF
- ☐ 72.2 pF
- ☒ 323 pF
- ☐ The answer depends on the voltage of the battery.

$Capacitance_{Total} = Capacitance_1 + Capacitance_2 + Capacitance_3 = 137+77+109 = 323\ pF$

(in parallel)

8) A 100 Watt lightbulb is connected to a standard house plug-in. What is the current flowing through that lightbulb?

- ☒ 0.83 A
- ☐ 1.2 A
- ☐ 144 A
- ☐ The answer depends on the resistance of the lightbulb.

$P = IV$

$I = \frac{P}{V} = \frac{100}{120} = 0.8\bar{3}\ A$

9) If all 4 resistors are identical and have a value of R Ω, what is the total resistance of the circuit to the right?

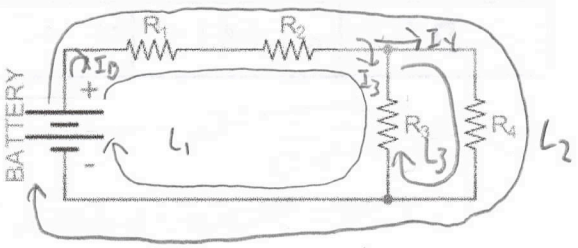
- ☐ (2/5)R Ω
- ☐ (3/4)R Ω
- ☐ (4/3)R Ω
- ☒ (5/2)R Ω

$R_{Total} = R + R + \frac{1}{\frac{1}{R}+\frac{1}{R}}$

$= R + R + \frac{R}{2}$

$= 2R + \frac{R}{2}$

$= 2.5R = \frac{5}{2}R$



10) Again, assuming all 4 resistors are the same value of R Ω, write two of the three loop equations for the circuit. You may earn 1 bonus point for providing all three equations.

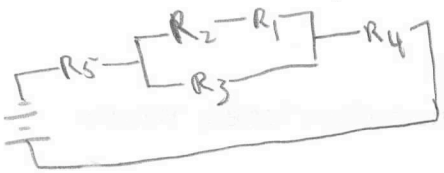
$V - I_B R_1 - I_B R_2 - I_3 R_3 = 0 \quad (L_1)$

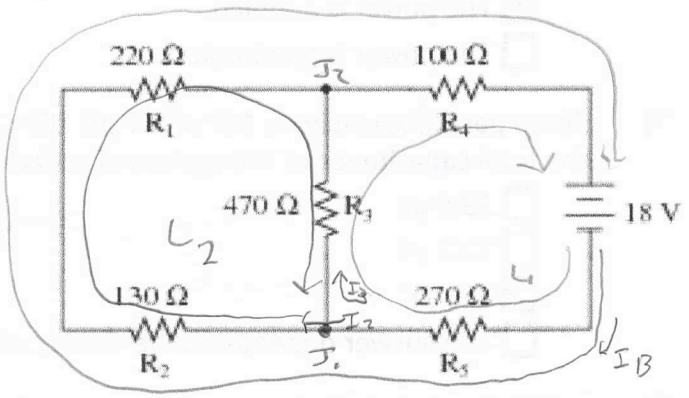
$V - I_B R_1 - I_B R_2 - I_4 R_4 = 0 \quad (L_2)$

$-I_4 R_4 + I_3 R_3 = 0 \quad (L_3)$

PSP Style: Solve the problem. Make sure to show all your work. (25 pts each)

11) Write the Kirchoff's Law Equations for the circuit below. Determine the current through each resistor. Determine the voltage across each resistor. Determine the Power used by each resistor.





L_1: $V - I_B R_5 - I_3 R_3 - I_B R_4 = 0$
L_2: $-I_2 R_2 - I_2 R_1 + I_3 R_3 = 0$
L_3: $V - I_B R_5 - I_2 R_2 - I_2 R_1 - I_B R_4 = 0$
J_1: $I_B = I_2 + I_3$
J_2: $I_2 + I_3 = I_B$

	R_1	R_2	R_3	R_4	R_5
V (V)	3.978	2.3505	6.328	3.155	8.517
I (A)	0.0181	0.0181	0.0135	0.0315	0.0315
R (Ω) (given)	220	130	470	100	270
P (W)	0.0719	0.0425	0.0852	0.0995	0.269

Units listed here

$R_{Total} = R_5 + \frac{1}{\frac{1}{R_2 + R_1} + \frac{1}{R_3}} + R_4 = 270 + \frac{1}{\frac{1}{130+220} + \frac{1}{470}} + 100 = 570.61\ \Omega$

$V = IR$, $I = V/R = 18/570.61 = 0.0315\ A$

I @ R_5 and $R_4 = I_B$

I @ R_1 and R_2

$-I_2 R_2 - I_2 R_1 + I_3 R_3 = 0$

$I_3 R_3 = I_2 (R_2 + R_1)$

$\frac{I_3 R_3}{R_2 + R_1} = I_2 = \frac{0.0135(470)}{220+130} = 0.0181\ A$

R_5

$V = IR = 0.0315 \cdot 270 = 8.517\ V$

$P = IV = 0.0315 \cdot 8.517 = 0.269\ W$

R_4

$V = IR = 0.0315 \cdot 100 = 3.15\ V$

$P = IV = 0.0315 \cdot 3.15 = 0.0995\ W$

R_3

$V - I_B R_5 - I_B R_4 - I_3 R_3 = 0$

$V - I_B (R_5 + R_4) = I_3 R_3$

$\frac{V - I_B (R_5 + R_4)}{R_3} = I_3 = \frac{18 - 0.0315(270+100)}{470} = 0.0135\ A$

$V = IR = 0.0135 \cdot 470 = 6.328\ V$

$P = IV = 0.0135 \cdot 6.328 = 0.0852\ W$

R_2

$V = IR = 0.0181 \cdot 130 = 2.353\ V$

$P = IV = 0.0181 \cdot 2.3505 = 0.0425\ W$

R_1

$V = IR = 0.0181 \cdot 220 = 3.978\ V$

$P = IR = 0.0181 \cdot 3.978 = 0.0719\ W$

assuming 20°C, cylindrical wire

12) Audio enthusiasts spend a lot of money on their stereos. When they connect loudspeakers to their amplifiers they commonly use 12-gauge (2.0525 mm diameter) copper wire. Some extreme audiophiles will use 18-gauge (1.0237 mm diameter) silver wire. The copper wire is $2.50 per meter, and the silver wire is $500.

a) • Determine the resistances for a 1.00 meter length of each wire.

b) • Which wire has the least resistance? If you had the money, could you justify the expense of the sliver wire? **Explain!**

a) $R = \rho \frac{l}{A} = \rho \frac{l}{\pi r^2} = \rho \frac{l}{\pi (\frac{d}{2})^2}$

copper $= 1.7e^{-8} \frac{1}{\pi (\frac{2.0525/1000}{2})^2} = 0.005138\ \Omega$

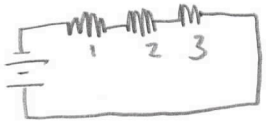
silver $= 1.59e^{-8} \frac{1}{\pi (\frac{1.0273/1000}{2})^2} = 0.019185\ \Omega$

b) Copper has less resistance. The only justification for the use of silver wire is if space was a bigger factor than resistance or simply to flaunt my wealth.

Complete the short-answer question below. Be aware the question may have multiple parts. You must answer all parts to receive full credit. Show all work. Partial credit may be given for partially correct or complete answers.

13) A set of 3, 1125 Ω-resistors are connected to a battery. There are 4 possible was to connect the resistors. Determine the equivalence resistance for each circuit. Rank them from lowest to highest resistance. (20 points)

Circuit 1 (C_1)

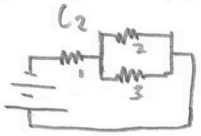


$R_{total} = R_1 + R_2 + R_3$

$= 1125 + 1125 + 1125$

$= 3375\ \Omega$

C_2

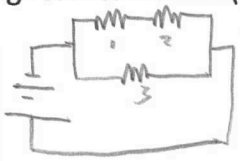


$R_{total} = R_1 + \frac{1}{\frac{1}{R_2} + \frac{1}{R_3}}$

$= 1125 + \frac{1}{\frac{1}{1125} + \frac{1}{1125}}$

$= 1687.5\ \Omega$

C_3

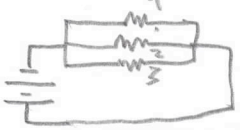


$R_{total} = \frac{1}{\frac{1}{R_1 + R_2} + \frac{1}{R_3}}$

$= \frac{1}{\frac{1}{1125 + 1125} + \frac{1}{1125}}$

$= 750\ \Omega$

C_4



$R_{Total} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$

$= \frac{1}{\frac{1}{1125} + \frac{1}{1125} + \frac{1}{1125}}$

$= 375\ \Omega$

lowest C_4, C_3, C_2, C_1 highest

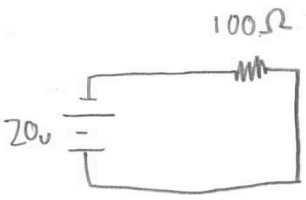
14) Create a **simple** circuit with a 100 Ω resistor which is connected to a 20 V battery. Use Kirchoff's Laws to **<u>prove</u>** you get the same values of current through each resistor for both clockwise loops and counter clockwise loops.

↑

(or)

Given the relationships between I_{max} and I_{RMS} and V_{max} and V_{RMS} prove that ...

$$P_{max} = 2 * P_{RMS}$$



$V - I_B R_1 = 0$, $V = I_B R_1$, $I_B = \frac{V}{R_1}$

$I_B R_1 - V = 0$, $I_B R_1 = V$, $I_B = \frac{V}{R_1}$

] Given the same V and R_1 values $I_B = I_B$ therefore the loop rule in both clockwise and counterclockwise directions yield the same current.

Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

TABLE 27.1 Resistivities and Temperature Coefficients of Resistivity for Various Materials

Material	Resistivity[a] ($\Omega \cdot m$)	Temperature Coefficient $\alpha[(°C)^{-1}]$
Silver	1.59×10^{-8}	3.8×10^{-3}
Copper	1.7×10^{-8}	3.9×10^{-3}
Gold	2.44×10^{-8}	3.4×10^{-3}
Aluminum	2.82×10^{-8}	3.9×10^{-3}
Tungsten	5.6×10^{-8}	4.5×10^{-3}
Iron	10×10^{-8}	5.0×10^{-3}
Platinum	11×10^{-8}	3.92×10^{-3}
Lead	22×10^{-8}	3.9×10^{-3}
Nichrome[b]	1.50×10^{-6}	0.4×10^{-3}
Carbon	3.5×10^{-5}	-0.5×10^{-3}
Germanium	0.46	-48×10^{-3}
Silicon	640	-75×10^{-3}
Glass	10^{10} to 10^{14}	
Hard rubber	$\approx 10^{13}$	
Sulfur	10^{15}	
Quartz (fused)	75×10^{16}	

[a] All values at 20°C.

[b] A nickel–chromium alloy commonly used in heating elements.