Total Score:

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Circuit Lab
Division C ANSWER KEY

School: _____

Team Number: _____

Team Members: _____

## Part I

1 C (2 points)

2 C (2 points)

3 A (2 points)

4 B (2 points)

5 D (2 points)

6 A (2 points)

7 B (2 points)

8 D (2 points)

9 B (2 points)

10 A (2 points)

11 Ronald Portugal (2 points)

12 Hans Oersted (2 points)

13 Donald Macadie (2 points)

14 Friedrich Drexler (2 points)

15 Thomas Edison (2 points)

## Part II

1 Use the formula $F = k_e \frac{q_1 q_2}{r^2}$, resulting in $8.99 * 10^9 * \frac{(24*10^{-3})(45)}{64^2} = 2.37 * 10^6$;
This is a repulsion, as they have the same sign, concluding that they repel against one another. Additionally, since the force is positive, it must be a repulsion. (6 points [3 points for correct number and 3 points for correct sign])

2 Coulomb's Law (2 points)

3 Coulomb's Constant (AKA electrostatic constant) is $8.99 * 10^9 \frac{N*m^2}{C^2}$ (2 points)

4 The law was first published in 1785 by French physicist Charles-Augustin de Coulomb (3 points[1 point for the correct year and 2 points for correct person])

5 Solving, you get $\frac{1}{\frac{1}{C3+C2+C1}+\frac{1}{C4+C5}} = \frac{1}{\frac{1}{500*(10^{-3})+500*(10^{-3})+1}+\frac{1}{500*(10^{-3})+5}} = \frac{1}{\frac{1}{2}+\frac{1}{5.5}} = 1.47$ (10 points)

6 $Q = C * V \rightarrow Q = 1.47 * 20 = 29.33$ (5 points)

7 $V_c = V_o(1 - e^{-t/(RC)}) \rightarrow 10\left(1 - e^{\frac{-23}{250}}\right) \rightarrow 0.88$ (5 points)

8 $Q = C * V \rightarrow 10V * 5F = 50$ (2 points)

## Part III

1 B (2 points)

2 C (2 points)

3 C (2 points)

4 True (2 points)

5 A (2 points)

6 Direct Current must be a straight line, while alternate current should be a sine wave (4 points [2 point for correct DC line, 2 point for correct AC line])

7 A (2 points)

## Part IV

1 $N_P \times I_P = N_S \times I_S \rightarrow 5 \times 10A = 20 \times I_S \rightarrow I_S = 2.5A$ or $5/2A$ (3 points)

2 $N_P \times V_S = N_S \times V_P \rightarrow 5 \times 400V = 20V \times N_S \rightarrow N_S = 100$ (3 points)

3:
A – Windings (2 points)

B – Brushes (2 points)

C – Rotor (2 points)

D – Commutator (2 points)

E – Magnet (2 points)

F – Stator (2 points)

G – Terminals (2 points)

4 Permanent Magnet, Series, Shunt, Compound (4 points [1 point for each correct])

5 Induction and Synchronous (2 points [1 point for each correct])

6 Rotor (2 points)

7 Stator (2 points)

## Part V

1 Variable DC Power Supply (2 points)

2 Potentiometer (2 points)

3 Fuse (2 points)

4 Zener Diode (2 points)

5 Integrated Circuit (2 points)

6 Motor (2 points)

7 $\frac{12}{(6+2)} = 1.5A$ or $3/2A$ (3 points)

8 $\frac{8}{(4+2)} = 1.33A$ or $4/3A$ (3 points)

9 $\frac{4}{3}A + \frac{3}{2}A = 2.83A$ or $17/6A$ (3 points)

10 $1.5A \times 6\Omega = 9A$ (3 points)

11 $1.33A \times 4\Omega = 5.33A$ or $16/3A$ (3 points)

12 $2.83A \times 2\Omega = 5.67A$ or $17/3A$ (3 points)

13
Step 1: Solve the first big area (R1-R9):
R1-R5 →120 $\Omega$
R6-R9 →100 $\Omega$
R1-R9 → 600/11 $\Omega$

Step 2: Solve R10-R14:
R13-R14 → 20 $\Omega$
R11-R14 → 600/17 $\Omega$
R10-R14 → 600/23 $\Omega$

Step 3: Solve R1-R15:
Add up to get 22930/253 $\Omega$ or 90.63 $\Omega$ (20 points)

## Part VI

1 Positive or + (2 points)

2 False (2 points)

3 Silicon PN Junction (2 points)

4 $v_{in} \times gain = v_{out} \rightarrow gain = -\frac{R_f}{R_{in}} \rightarrow v_{out} = -15V$ (4 points)

5 $gain = -\frac{R_f}{R_{in}} \rightarrow -\frac{3}{4}$ or $-0.75$ (4 points)

6 $v_{in} \times gain = v_{out} \rightarrow gain = 1 + \frac{R_2}{R_1} \rightarrow v_{out} = 35V$ (4 points)

7 $gain = 1 + \frac{R_2}{R_1} \rightarrow v_{out} = \frac{7}{4}$ or $1.75$ (4 points)

## Part VII

1 1 (2 points)

2 1 (2 points)

3 0 (2 points)

4 1 (2 points)

5 0 (2 points)

6 1 (2 points)

7 1 (2 points)

8 1 (2 points)

9 0 (2 points)

10 1 (2 points)

11 0 (5 points)