FULL NAME (Printed): * SOLUTIONS *

Program:

You have 50 minutes to complete this examination. You are allowed your Sharp EL-516 calculator and the DC Formula Sheet from the text (provided).

- **M/C Questions**
  - Circle the correct answer
  - NO partial credit will be awarded
- **Work the Problem Questions**
  - SHOW ALL your work in the space provided
  - BOX-IN your final answer
  - Partial credit may be awarded

$\mu \Rightarrow 10^{-6}$ $p \Rightarrow 10^{-12}$

1. One microfarad is equivalent to how many picofarads?
   a. 10
   b. 1,000
   c. 100,000
   d. 1,000,000

ADD 6 ZEROS

2. The value 10 megawatts is equivalent to
   a. 100×10^3 watts
   b. 10×10^6 watts
   c. 100×10^{-3} watts
   d. 100×10^{-6} watts

10×10^6 W

3. Evaluate the following expression: $(15 \times 10^{-6})/(5 \times 10^{-9})$ =
   a. 3×10^{-3}
   b. 3×10^3
   c. 0.03
   d. 300

3000

4. Express the number .00003597 using the powers of ten.
   a. 3597×10^{-5}
   b. 3.597×10^{-5}
   c. 35.97×10^{-4}
   d. 359.7×10^{-6}

5 PLACES

35.97×10^{-6}

OR

3.597×10^{-5}

5. What is the current (in amperes) if 10.0 coulombs of charge pass through a wire in 2.0 seconds?
   a. 0.2 amperes
   b. 5 amperes
   c. 10 amperes
   d. 20 amperes

$$I = \frac{Q}{t} = \frac{10.0C}{2.0\,Sec} = \underline{5A}$$

6. How much energy is expended in moving a 20 coulomb charge through a potential difference of 0.5 volts?
   a. 0.025 joules
   b. 10 joules
   c. 20 joules
   d. 40 joules

$$V = \frac{W}{Q} \frac{(JOULES)}{(Coulombs)}$$

$$\therefore W = V \cdot Q = (0.5V)(20C) = \underline{10J}$$

7. A 9-volt battery with a 500 mAh capacity is connected to a circuit which draws 100 mA. How long will the battery be able to power this circuit?
   a. 0.05 hours
   b. 0.2 hours
   c. 0.5 hours
   d. 5 hours

$$\frac{500\,mAh}{100\,mA} = \underline{5\ hours}$$

8. How must ammeters be connected in a circuit when used to measure current?
   a. Directly across the component
   b. Varies with the component being measured
   c. Varies with circuit construction
   d. In series with the component being measured

9. Which of these color code patterns is found on a 270 Ohm, 5% resistor?
   a. red, violet, brown, silver
   b. red, violet, brown, gold
   c. red, violet, black, silver
   d. red, violet, brown, no 4th band

RED VIOLET BROWN GOLD

10. Four 470 Ohm +/- 5% resistors are measured with an ohmmeter. One of the measured resistor values is not within the 5% tolerance. Which *one* of the following readings is out of bounds?
    a. 445.0 *Ohms*
    b. 470.6 *Ohms* ✓
    c. 476.0 *Ohms* ✓
    d. 490.0 *Ohms* ✓

WITHIN +/- 5%

470Ω +/- 5%

$\rightarrow$ 446.5Ω TO 493.5Ω

11. What voltage is developed across a 470 Ohm resistor if 50 mA of current flows through it?
 a. 0.24 V
 b. 2.34 V
 c. 9.40 V
 d. 23.5 V

$\frac{V}{I | R}$ $V_R = I \cdot R$
$= (50 mA)(470\Omega)$
$V_R = \underline{23.5V}$

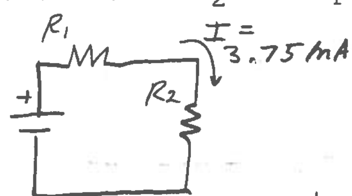
12. How many joules of energy will a 10 watt lamp dissipate in one minute?
 a. 10 joules
 b. 60 joules
 c. 600 joules
 d. 3600 joules

$P = \frac{W}{t} \therefore W = P \cdot t$
$= (10W)(60 sec)$
$= 600 W \cdot S$ OR
$\underline{600 J}$

13. 50 mA of current flow through a 10 k-Ohm resistor. How much *power* is dissipated?
 a. 0.25 uW
 b. 5 uW
 c. 25 W
 d. 500 W

$P = V \cdot I$
V^2/R
$I^2 \cdot R$
$P_R = (50 mA)^2 (10k\Omega)$
$= \underline{25W}$

14. A series circuit consists of a source voltage and two resistors R_1 and R_2. The resistors dissipate a total of 56.25 mW of power and the current in the circuit is 3.75 mA. If R_2 dissipates 21.09 mW of power, what is the value of R_1?
 a. 1000 ohms
 b. 1500 ohms
 c. 2000 ohms
 d. 2500 ohms



$P_{R2} = 21.09 mW$
$P_T = P_{R1} + P_{R2} = 56.25 mW$

$P_{R1} = P_T - P_{R2}$
$\underline{P_{R1} = 35.16 mW} = I_{R1}^2 \cdot R_1$
$I_{R1} = I = 3.75 mA$
$\therefore R_1 = \frac{P_{R1}}{I_{R1}^2} = \frac{35.16mW}{(3.75 mA^2)}$
$= \underline{2,500\Omega}$

15. Which of the following will apply to the largest resistor in a series circuit?
 a. It will have the largest current going through it ×
 b. It will have the greatest voltage drop
 c. It will have a voltage drop equal to the other resistors in the circuit ×

$V = I \cdot R$

SINCE "I" IS THE SAME FOR ALL COMPONENTS IN A SERIES CIRCUIT

16. Use the conversion factor 1 watt = 0.00134 horsepower to determine the amount of power (in watts) produced by a 20 hp riding lawn mower engine.

$$(20hp)\left(\frac{1W}{0.00134\,hp}\right) = \underline{\underline{14,925\,W}}$$

a. 26.8 mW
b. 134 W
c. 7.46 kW
d. 14.93 kW

17. The inferred absolute temperature for copper is -243.5 Deg C. If the resistance of a copper wire is 10 Ohms at 25 Deg C, what is its resistance at 200 Deg C?

$$\frac{|T_{ABS}| + T_1}{R_1} = \frac{|T_{ABS}| + T_2}{R_2}$$

$|T_{ABS}| = 243.5^\circ C$

$T_1 = 25^\circ C,\ R_1 = 10\Omega$

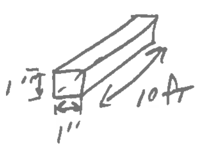
$T_2 = 200^\circ C,\ R_2 = ?$

$\therefore R_2 = \underline{\underline{16.52\Omega}}$

a. 16.5 ohms
b. 15.6 ohms
c. 12.3 ohms
d. 7.5 ohms

18. Compute the resistance of a 1" x 1" square copper bar 10 feet long. The resistivity of copper is 10.37 (CM-Ohm)/ft.

Recall: 1 square mil = 4/π CM (circular mils)



$$R = \rho\frac{\ell}{A} = \left(10.37\ \frac{CM\text{-}\Omega}{ft}\right)\left(\frac{10ft}{A\ CM}\right)$$, NEED "A" IN CM

$A = 1'' \times 1'' = 1$ SQ INCH $= 1000$ MIL $\times 1000$ MIL $= \underline{1\times10^6 \text{ SQ MILS}}$

BUT 1 SQ MIL $= \frac{4}{\pi}$ CM

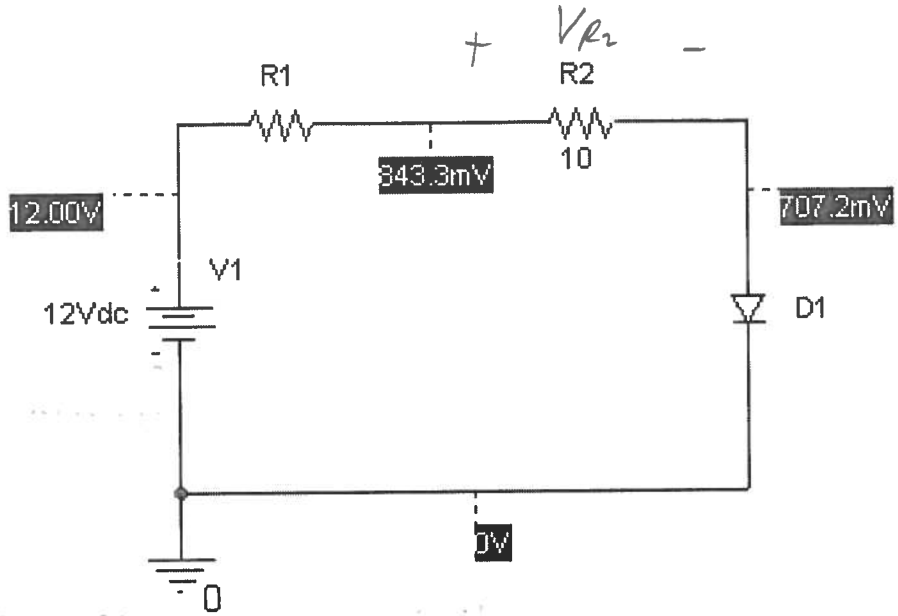
$$\therefore A = (1\times10^6\ \text{SQ MILS})\left(\frac{4}{\pi}\ \frac{CM}{\text{SQ MIL}}\right) = \underline{1.273\times10^6\ CM}$$

$$\therefore R = \left(10.37\ \frac{CM\text{-}\Omega}{ft}\right)\left(\frac{10ft}{1.273\times10^6\ CM}\right) = \boxed{81.45\mu\Omega}$$

19. Using Ohm's Law, find I when the voltage V = 9.3 Volts and R = 820 Ohms.

$$\frac{V}{I\,|\,R}$$

$$I = \frac{V}{R} = \frac{9.3V}{820\Omega} = \boxed{11.34\ mA}$$



*** The voltages given in the figure above are with respect to ground. For example, the voltage across R1 is (12.00V-843.3mV) = 11.16V. ***

20. Given the circuit shown above, calculate the power dissipated by R2.

$$P_{R2} = \frac{V_{R2}^2}{R2} = \frac{(843.3\,mV - 707.2\,mV)^2}{10\Omega} = \boxed{1.85\,mW}$$

KEY

1. d
2. b
3. b
4. b

5. b
6. b
7. d
8. d
9. b
10. a

11. d
12. c
13. c
14. d
15. b

16. d
17. a
18. 81.5 μ-*Ohms*
19. 11.3 milliamps

20. 1.86 mW

Summary of Equations to Accompany

INTRODUCTORY CIRCUIT ANALYSIS, Thirteenth Edition, by Robert L. Boylestad

dc

Introduction

Conversions 1 meter = 100 cm = 39.37 in., 1 in. = 2.54 cm, 1 yd = 0.914 m = 3 ft, 1 mile = 5280 ft. °F = 9/5°C + 32, °C = 5/9(°F − 32), K = 273.15 + °C **Scientific notation** 10^{12} = tera = T, 10^{9} = giga = G, 10^{6} = mega = M, 10^{3} = kilo = k, 10^{-3} = milli = m, 10^{-6} = micro = μ, 10^{-9} = nano = n, 10^{-12} = pico = p **Powers of ten** $1/10^n = 10^{-n}$, $1/10^{-n} = 10^n$, $(10^n)(10^m) = 10^{n+m}$, $10^n/10^m = 10^{n-m}$, $(10^n)^m = 10^{nm}$

Voltage and Current

Coulomb's law $F = kQ_1Q_2/r^2$, $k = 9 \times 10^9\ \mathrm{N \cdot m^2/C^2}$, Q = coulombs (C), r = meters (m) **Current** $I = Q/t$ (amperes), t = seconds (s), $Q_e = 1.6 \times 10^{-19}$ C **Voltage** $V = W/Q$ (volts), W = joules (J)

Resistance

Circular wire $R = \rho l/A$ (ohms), ρ = resistivity, l = feet, $A_{CM} = (d_{mils})^2$, $\rho(\mathrm{Cu}) = 10.37$ **Metric units** l = cm, $A = \mathrm{cm}^2$, $\rho(\mathrm{Cu}) = 1.724 \times 10^{-6}$ ohm-cm **Temperature** $(|T_i| + T_1)/R_1 = (|T_i| + T_2)/R_2$, $R_1 = R_{20}[1 + \alpha_{20}(T_1 - 20°\mathrm{C})]$, $\alpha_{20}(\mathrm{Cu}) = 0.00393$ **Color code** Bands 1–3: 0 = black, 1 = brown, 2 = red, 3 = orange, 4 = yellow, 5 = green, 6 = blue, 7 = violet, 8 = gray, 9 = white, Band 3: 0.1 = gold, 0.01 = silver, Band 4: 5% = gold, 10% = silver, 20% = no band, Band 5: 1% = brown, 0.1% = red, 0.01% = orange, 0.001% = yellow **Conductance** $G = 1/R$ siemens (S)

Ohm's Law, Power, and Energy

Ohm's law $I = E/R$, $E = IR$, $R = E/I$ **Power** $P = W/t = VI = I^2R = V^2/R$ (watts), 1 hp = 746 W
Efficiency $\eta\% = (P_o/P_i) \times 100\%$, $\eta_T = \eta_1 \cdot \eta_2 \cdot \eta_3 \cdots \eta_n$
Energy $W = Pt$, $W(\mathrm{kWh}) = [P(\mathrm{W}) \cdot t(\mathrm{h})]/1000$

Series Circuits

$R_T = R_1 + R_2 + R_3 + \cdots + R_N$, $R_T = NR$, $I = E/R_T$, $V = IR$
Kirchhoff's voltage law $\Sigma_{\circlearrowright} V = 0$, $\Sigma_{\circlearrowright} V_{rises} = \Sigma_{\circlearrowright} V_{drops}$
Voltage divider rule $V_x = R_xE/R_T$

Parallel dc Circuits

$R_T = 1/(1/R_1 + 1/R_2 + 1/R_3 + \cdots + 1/R_N)$, $R_T = R/N$, $R_T = R_1R_2/(R_1 + R_2)$, $I = EG_T = E/R_T$
Kirchhoff's current law $\Sigma I_{entering} = \Sigma I_{leaving}$
Current divider rule $I_x = (R_T/R_x)I$, (Two parallel elements): $I_1 = R_2I/(R_1 + R_2)$, $I_2 = R_1I/(R_1 + R_2)$

Series-Parallel Circuits

Potentiometer loading $R_L >> R_T$
Ammeter $R_{shunt} = R_mI_{CS}/(I_{max} - I_{CS})$
Voltmeter $R_{series} = (V_{max} - V_{VS})/I_{CS}$
Ohmmeter $R_s = (E/I_{CS}) - R_m - \text{zero-adjust}/2$

Methods of Analysis and Selected Topics (dc)

Source conversions $E = IR_p$, $R_s = R_p$, $I = E/R_s$
Determinants $D = \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} = a_1b_2 - a_2b_1$
Bridge networks $R_1/R_3 = R_2/R_4$ **Δ-Y conversions** $R' = R_A + R_B + R_C$, $R_3 = R_AR_B/R'$, $R_2 = R_AR_C/R'$, $R_1 = R_BR_C/R'$, $R_Y = R_\Delta/3$
Y-Δ conversions $R'' = R_1R_2 + R_1R_3 + R_2R_3$, $R_C = R''/R_3$, $R_B = R''/R_2$, $R_A = R''/R_1$, $R_\Delta = 3R_Y$

Network Theorems

Superposition Voltage sources (short-circuit equivalent), current sources (open-circuit equivalent)
Thévenin's Theorem R_{Th}: (all sources to zero), E_{Th}: (open-circuit terminal voltage)
Maximum power transfer theorem $R_L = R_{Th} = R_N$, $P_{max} = E^2_{Th}/4R_{Th} = I^2_NR_N/4$

Capacitors

Capacitance $C = Q/V = \epsilon A/d = 8.85 \times 10^{-12}\epsilon_r A/d$ farads (F), $C = \epsilon_r C_o$ **Electric field strength** $\mathscr{E} = V/d = Q/\epsilon A$ (volts/meter) **Transients** (charging) $i_C = (E/R)e^{-t/\tau}$, $\tau = RC$, $v_C = E(1 - e^{-t/\tau})$, (discharge) $v_C = Ee^{-t/\tau}$, $i_C = (E/R)e^{-t/RC}$ i_C $i_{C_{av}} = C(\Delta v_C/\Delta t)$ **Series** $Q_T = Q_1 = Q_2 = Q_3$, $1/C_T = (1/C_1) + (1/C_2) + (1/C_3) + \cdots + (1/C_N)$, $C_T = C_1C_2/(C_1 + C_2)$ **Parallel** $Q_T = Q_1 + Q_2 + Q_3$, $C_T = C_1 + C_2 + C_3$ **Energy** $W_C = (1/2)CV^2$

Inductors

Self-inductance $L = N^2\mu A/l$ (henries), $L = \mu_r L_o$
Induced voltage $e_{L_{av}} = L(\Delta i/\Delta t)$ **Transients** (storage) $i_L = I_m(1 - e^{-t/\tau})$, $I_m = E/R$, $\tau = L/R$, $v_L = Ee^{-t/\tau}$ (decay), $v_L = [1 + (R_2/R_1)]Ee^{-t/\tau'}$, $\tau' = L/(R_1 + R_2)$, $i_L = I_me^{-t/\tau'}$, $I_m = E/R_1$
Series $L_T = L_1 + L_2 + L_3 + \cdots + L_N$ **Parallel** $1/L_T = (1/L_1) + (1/L_2) + (1/L_3) + \cdots + (1/L_N)$, $L_T = L_1L_2/(L_1 + L_2)$
Energy $W_L = 1/2(LI^2)$

Magnetic Circuits

Flux density $B = \Phi/A$ (webers/m²) **Permeability** $\mu = \mu_r\mu_o$ (Wb/A · m)
Reluctance $\mathscr{R} = l/\mu A$ (rels) **Ohm's law** $\Phi = \mathscr{F}/\mathscr{R}$ (webers)
Magnetomotive force $\mathscr{F} = NI$ (ampere-turns) **Magnetizing force** $H = \mathscr{F}/l = NI/l$ **Ampère's circuital law** $\Sigma_{\circlearrowright} \mathscr{F} = 0$
Flux $\Sigma \Phi_{entering} = \Sigma \Phi_{leaving}$ **Air gap** $H_g = 7.96 \times 10^5 B_g$

Greek Alphabet

Letter	Capital	Lowercase	Letter	Capital	Lowercase
Alpha	A	α	Nu	N	ν
Beta	B	β	Xi	Ξ	ξ
Gamma	Γ	γ	Omicron	O	ο
Delta	Δ	δ	Pi	Π	π
Epsilon	E	ε	Rho	P	ρ
Zeta	Z	ζ	Sigma	Σ	σ
Eta	H	η	Tau	T	τ
Theta	Θ	θ	Upsilon	Υ	υ
Iota	I	ι	Phi	Φ	ϕ
Kappa	K	κ	Chi	X	χ
Lambda	Λ	λ	Psi	Ψ	ψ
Mu	M	μ	Omega	Ω	ω

Prefixes

Multiplication Factors	SI Prefix	SI Symbol
1 000 000 000 000 000 000 = 10^{18}	exa	E
1 000 000 000 000 000 = 10^{15}	peta	P
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a