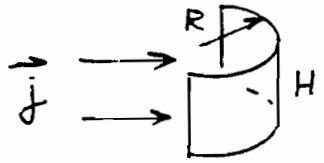
CURRENT AND RESISTANCE

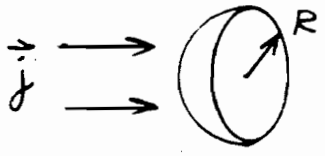
$$V = iR \qquad E = j\rho \qquad P = Vi = i^2R = V^2/R$$

1. IN TERMS OF CURRENT DENSITY j [AMPS/m^2] AND THE GEOMETRIC MEASUREMENTS, FIND A FORMULA FOR THE CURRENT i [AMPS].

A) SEMI-CYLINDER

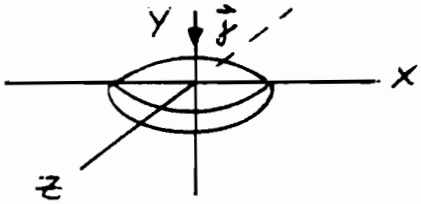


B) HEMISPHERE



C) SEMI-ELLIPSOID

$$\frac{x^2}{A^2} + \frac{y^2}{B^2} + \frac{z^2}{C^2} = 1$$



D) FLAT PLATE OF AREA "A" HIT AT A GLANCING ANGLE.

2. A CABLE, WHOSE CROSS-SECTIONAL AREA IS .0012 m^2, CARRIES A CURRENT OF 42 AMPS. FIND ITS CURRENT DENSITY.

3. AN IRON WIRE HAS CURRENT DENSITY OF 4.8×10^6 A/m^2. EACH IRON ATOM CONTRIBUTES TWO VALENCE ELECTRONS TO THE "SEA OF ELECTRONS," WHICH CONSTITUTES THE CURRENT. IRON, WHOSE ATOMIC MASS IS 56 g/mole, HAS A DENSITY OF 7.9 g/cm^3. FIND THE DRIFT VELOCITY OF THE ELECTRONS.

4. A STEEL TROLLY RAIL, WHOSE CROSS-SECTIONAL AREA IS 45 cm^2, HAS A RESISTIVITY OF $1.8 \times 10^{-7}\ \Omega \cdot m$. FIND THE TOTAL RESISTANCE OF A TRACK 12.5 km LONG.

5. SILVER HAS A RESISTIVITY OF $1.6 \times 10^{-8}\ \Omega \cdot m$. FIND ITS CONDUCTIVITY.

ANSWERS:

$i = 2RHj$	$i = -\pi R^2 j$	$i = \pi AC j$	$i = Aj\cos\theta$
35000 A/m^2	.177 mm/sec	.5 Ω	6.25×10^7 S.

6. TUNGSTEN HAS A TEMPERATURE COEFFICIENT OF RESISTIVITY OF 4.5×10^{-3} /C°. AT 25°C, THE TUNGSTEN ELEMENT IN A TOASTER HAS A RESISTANCE OF 30 Ω. WHEN THE TOASTER IS DOING EXACTLY THAT TO THE BREAD, THE ELEMENT'S TEMPERATURE IS 625°C. FIND THE RESISTANCE OF THE ELEMENT AT THIS HIGHER TEMPERATURE. (111 Ω)

7. ON THE SURFACE OF THE EARTH, AT 20°C, A CARBON RESISTOR HAS A VALUE OF 160 Ω. THE RESISTOR, WHOSE TEMPERATURE COEFFICIENT OF RESISTIVITY IS -5×10^{-4} /C°, IS LOWER TO THE BOTTOM OF AN OIL WELL WHERE ITS RESISTANCE IS 154 Ω. FIND THE:

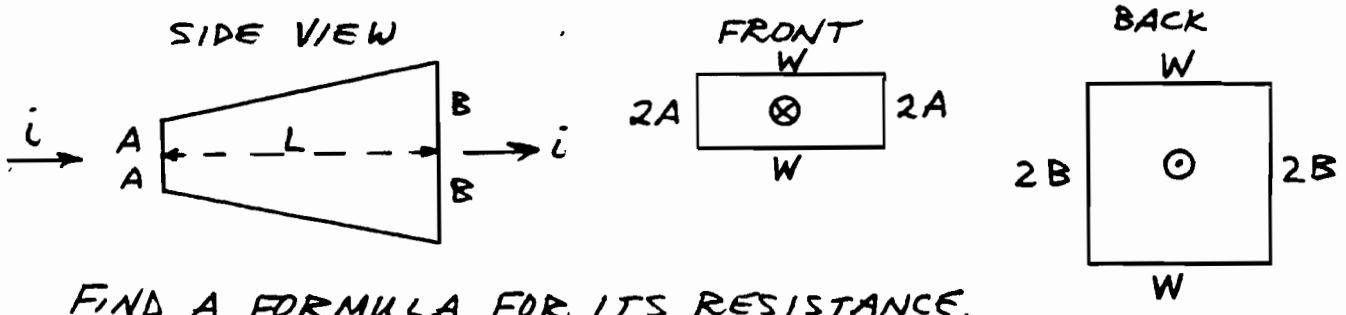
A) CHANGE IN TEMPERATURE (75 C°)

B) TEMPERATURE AT THE BOTTOM OF THE WELL. (95°C)

8. TWO WIRES HAVE THE SAME RESISTANCE AND THE SAME CROSS SECTIONAL AREA. HOWEVER, THEY HAVE BOTH DIFFERENT LENGTHS AND DIFFERENT RESISTIVITIES. FIND A FORMULA FOR L_2 IN TERMS OF L_1, ρ_1 AND ρ_2, WHERE L IS LENGTH AND ρ IS RESISTIVITY.

9. FIND A FORMULA FOR THE RESISTANCE, "R", OF A WIRE IN TERMS OF ITS RESISTIVITY "ρ", ITS MASS "m," ITS DENSITY "D" AND THE RADIUS, "r," OF ITS CROSS SECTION.

10. A TRUNCATED WEDGE, WITH RESISTIVITY ρ, HAS THE DIMENSIONS SHOWN BELOW.



FIND A FORMULA FOR ITS RESISTANCE, IN TERMS OF L, W, A, B AND ρ.

ANSWERS: PROBLEM 8 $L_2 = \frac{\rho_1 L_1}{\rho_2}$ 9. $R = \frac{\rho m}{\pi^2 r^4 D}$ 10. $R = \frac{\rho L}{2W(B-A)} \ln\left(\frac{B}{A}\right)$

11. A TRANSMISSION LINE BETWEEN A POWER STATION AND A FACTORY HAS A RESISTANCE OF .15 Ω IN EACH OF THE TWO WIRES.

A) A CURRENT OF 200 A IS DELIVERED TO THE FACTORY AT 110 VOLTS. FIND:

i) POWER DELIVERED TO THE FACTORY (22,000 w)

ii) POWER WASTED TO HEAT BOTH WIRES (12,000 w)

iii) TOTAL POWER GENERATED BY SAN ONOFRE (34,000 w)

iv) PERCENT OF TOTAL POWER WASTED. (35.3%)

B) A CURRENT OF 2 AMP IS DELIVERED TO THE FACTORY AT 11,000 VOLTS. FIND:

i) POWER DELIVERED TO FACTORY (22,000 w)

ii) POWER WASTED TO HEAT BOTH WIRES (1.2 w)

iii) TOTAL POWER GENERATED BY SAN ONOFRE (22,001.2)

iv) PERCENT OF TOTAL POWER WASTED. (.00545%)

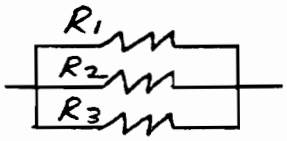
MORAL OF THE STORY: TRANSPORT ELECTRICAL ENERGY AT VERY HIGH VOLTAGE AND CONSEQUENTLY, VERY LOW CURRENT.

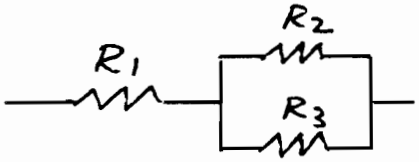
CIRCUITS: OHM ON THE RANGE — WHERE THE SKIES ARE UNCLOUDY ALL DAY

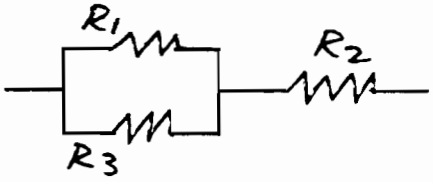
1. FIND THE EQUIVALENT RESISTANCE FOR EACH OF THE FOLLOWING COMBINATIONS WHERE:

$R_1 = 132\ \Omega$ $R_2 = 15\ \Omega$ $R_3 = 60\ \Omega$

A) 

B) 

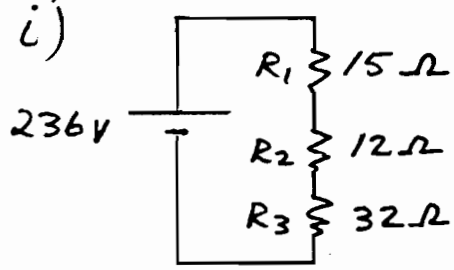
C) 

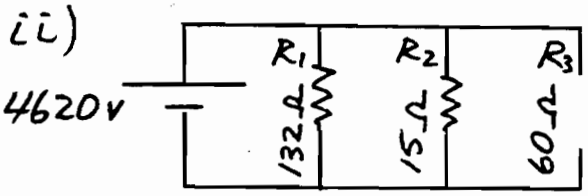
D) 

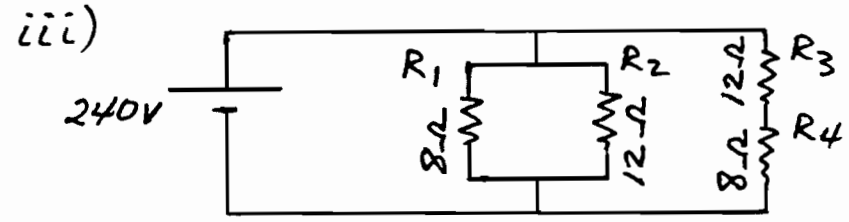
(207 Ω, 11 Ω, 144 Ω, 56.25 Ω)

2. FOR EACH CIRCUIT, FIND:

A) CURRENT FLOWING THROUGH EACH RESISTOR
B) VOLTAGE DROP ACROSS EACH RESISTOR
C) POWER SUPPLIED TO EACH RESISTOR
D) TOTAL CURRENT FLOWING THROUGH THE BATTERY
E) TOTAL POWER SUPPLIED BY THE BATTERY

i) 

ii) 

iii) 

ANSWERS: i) 4, 4, 4 A; 60, 48, 128 V; 240, 192, 512 W; 4 A; 944 W.

ii) 35, 308, 77 A; 4620, 4620, 4620 V; 161700, 1422960, 355740 W; 420 A; 1940400 W.

iii) 30, 20, 12, 12 A; 240, 240, 144, 96 V; 7200, 4800, 1728, 1152 W; 62 A, 14 880 W.

3. SUPER MAX! TANIA'S 1000 WATT HAIR DRYER OPERATES WITH A VOLTAGE OF 120V. CALCULATE THE DRYER'S CURRENT AND RESISTANCE. (8.33 A, 14.4 Ω)

4. AN ELEVATOR CARRIES 800 KG FROM GROUND LEVEL TO A HEIGHT OF 200 m IN 10 MINUTES.

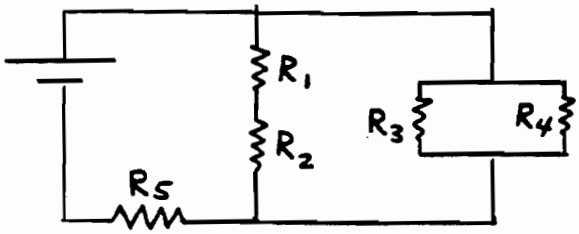
A) CALCULATE THE WORK DONE BY THE ELEVATOR.

RECALL: $PE_0 + KE_0 \pm \text{WORK} = PE + KE$ $(1.6 \times 10^6 \text{ J})$

B) HOW MUCH POWER IS EXPENDED? (2667 WATTS)

C) IF THE MOTOR RUNS AT 240V AND IS 30% EFFICIENT, WHAT CURRENT DOES IT REQUIRE? (37 A)

KIRCHOFF'S LAW: INTUITIONS: FILL IN THE CHART



GIVEN INFORMATION:

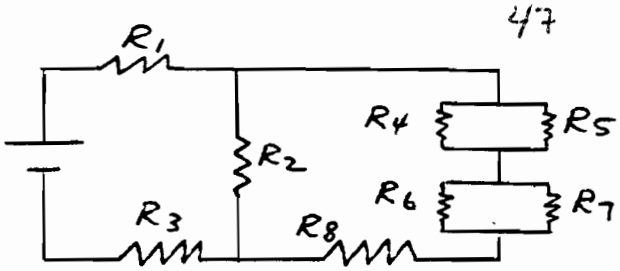
$i_{\text{BATTERY}} = 20 \text{ A}$ $V_2 = 3 \text{ V}$

$i_1 = 2 \text{ A}$ $V_3 = 10 \text{ V}$

$i_4 = 4 \text{ A}$ $V_5 = 5 \text{ V}$

	V	i	POWER	R
BATTERY				—
R_1				
R_2				
R_3				
R_4				
R_5				

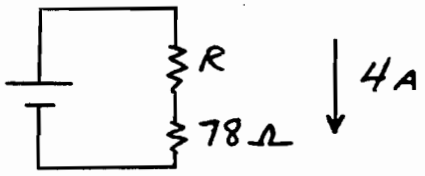
3. FOR THE CIRCUIT SHOWN, FILL IN THE UNKNOWN QUANTITIES IN THE CHART BELOW.



	BATTERY	1	2	3	4	5	6	7	8	
I					12 AMPS			15 AMPS		A
V	1250V								200 V	V
R	–		32 Ω			45 Ω			10 Ω	Ω
P	56250 WATTS			12150 WATTS						W

4. TWO RESISTORS ARE COMBINED IN SERIES AND IN PARALLEL. THE MAXIMUM VALUE OF THE COMBINATION IS 294 Ω. THE MINIMUM IS 36 Ω. MAKE LIKE SHERLOCK 'OLMES AND DETERMINE THE VALUES OF THE INITIAL RESISTORS. (42 Ω, 252 Ω)

5. INITIALLY, A RESISTOR HAS 7 AMPS FLOWING THROUGH IT. A 78 Ω RESISTOR IS NOW CONNECTED IN SERIES WITH THE FIRST. THE CURRENT FLOWING THROUGH THEM IS NOW ONLY 4 AMPS. FIND THE VALUE OF THE FIRST RESISTOR.



(104 Ω)

6. INITIALLY, A RESISTOR HAS 30 AMPS FLOWING THROUGH IT. A 90 Ω RESISTOR IS NOW CONNECTED IN PARALLEL WITH THE FIRST. THE TOTAL CURRENT SUPPLIED BY THE BATTERY IS NOW 36 AMPS. FIND THE VALUE OF THE INITIAL RESISTOR. (18 Ω)

7. A 465 V BATTERY IS CONNECTED TO A 12 Ω RESISTOR. THE RESISTOR RECEIVES 11532 WATTS OF POWER. FIND:

A) CURRENT FLOWING THROUGH THE RESISTOR.
B) INTERNAL RESISTANCE OF THE BATTERY.
C) VOLTAGE DROP ACROSS EACH RESISTANCE.
D) POWER DISSIPATED BY THE INTERNAL RESISTANCE OF THE BATTERY.
E) PERCENT OF POWER WASTED BY THE INTERNAL RESISTANCE.

(31 A, 3 Ω, 372 V, 93 V, 2883 W, 20%)

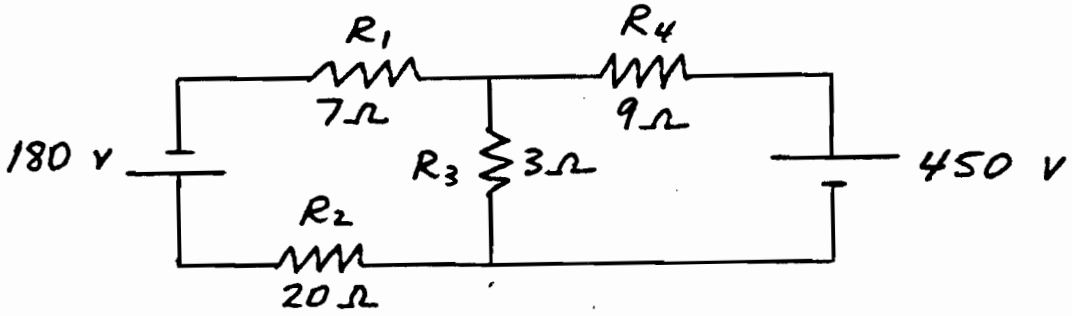
8. A 465 V BATTERY WHOSE INTERNAL RESISTANCE IS 3 Ω IS CONNECTED TO A MOTOR WHOSE RESISTANCE IS ALSO 3 Ω. FIND:

A) CURRENT FLOWING AROUND THE CIRCUIT.
B) VOLTAGE DROP ACROSS EACH RESISTOR,
C) POWER DELIVERED TO EACH RESISTOR.
D) PERCENT OF POWER WASTED BY THE INTERNAL RESISTANCE. (77.5 A, 232.5 V, 18018.75 W, 50%)

9. FOR THE FOLLOWING CIRCUITS, FIND THE:

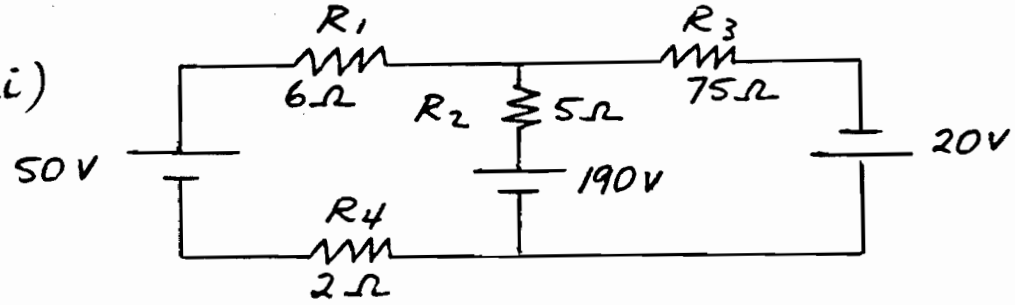
A) CURRENT FLOWING THROUGH EACH RESISTOR AND THROUGH EACH BATTERY
B) DROP IN VOLTAGE ACROSS EACH RESISTOR.
C) POWER SUPPLIED TO EACH RESISTOR.
D) POWER SUPPLIED BY EACH BATTERY.

i)



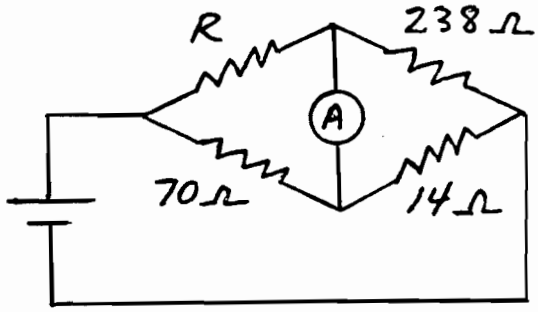
(10, 10, 30, 40, 10, 40 A; 70, 200, 90, 360 V; 700, 2000, 2700, 14400 W; 1800, 18000 W)

ii)



(10, 12, 2, 10, -10, 12, 2 A; 60, 60, 150, 20 V; 600, 720, 300, 200 W; 500 W CHARGING BATTERY, 2280, 40 W)

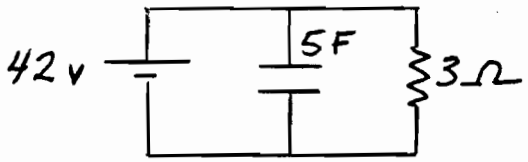
10. THE AMMETER OF A WHEATSTONE BRIDGE CIRCUIT READS ZERO. FIND THE VALUE OF THE UNKNOWN RESISTOR.
(1190 Ω)



11. THE CIRCUIT SHOWN BELOW IS PRESENTLY AT EQUILIBRIUM, THE CURRENT HAVING BEEN FLOWING FOR A VERY LONG TIME. FIND:

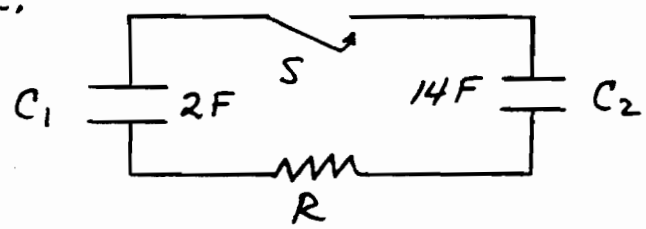
A) THE CHARGE AND THE ENERGY STORED IN THE CAPACITOR.

B) THE CURRENT FLOWING THROUGH THE RESISTOR AND THE POWER DELIVERED TO IT.



(210 C, 4410 J; 14 A, 588 W)

12.



INITIALLY, C_2 IS UNCHARGED, THE SWITCH IS OPEN AND C_1 IS CHARGED TO A POTENTIAL OF 120 V.

A) FIND THE CHARGE AND ENERGY INITIALLY STORED IN C_1. (240 C, 14400 J)

B) THE SWITCH IS NOW CLOSED ALLOWING CHARGE TO FLOW FROM C_1 TO C_2 UNTIL THEIR VOLTAGES ARE EQUAL. AT THAT TIME, THE CIRCUIT IS IN EQUIL-

IBRIUM AND THE CHARGES STOP FLOWING. FIND THE:

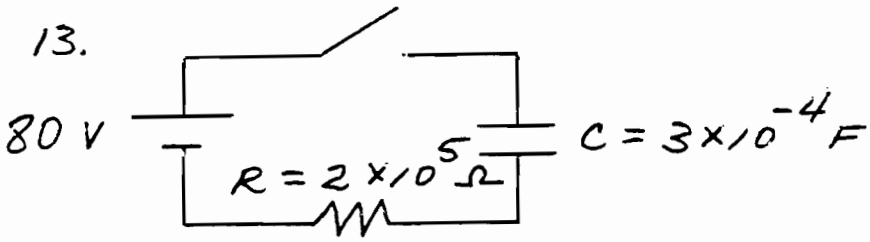
i) CHARGE STORED BY EACH CAPACITOR (30 C, 20 C)

ii) VOLTAGE ACROSS EACH CAPACITOR (15 V, 15 V)

iii) ENERGY STORED BY EACH CAPACITOR (225 J, 1575 J)

C) FIND THE TOTAL ENERGY DISSIPATED BY THE RESISTOR WHILE THE CURRENT WAS FLOWING. (12600 J)

13.



A) FIND THE DECAY CONSTANT FOR THIS CIRCUIT.

B) AT $t = 0$, WE CLOSE THE SWITCH. FOR $t = 15$ SECONDS, FIND THE:

i) CHARGE STORED IN THE CAPACITOR.

ii) CURRENT FLOWING THROUGH THE RESISTOR.

iii) DROP IN POTENTIAL ACROSS THE CAPACITOR.

iv) DROP IN POTENTIAL ACROSS THE RESISTOR.

(60 sec, 5.31×10^{-3} C, 3.11×10^{-4} A, 17.3 V, 62.3 V)

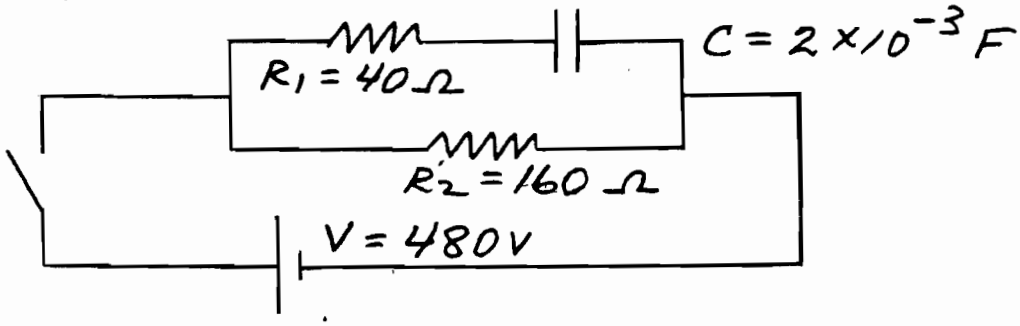
14. FOR THE CIRCUIT IN PROBLEM 13,

A) AT $t = 0$, JUST AFTER CLOSING THE SWITCH, FIND THE CHARGE ON THE CAPACITOR, THE CURRENT, THE VOLTAGE ACROSS THE CAPACITOR AND THE VOLTAGE ACROSS THE RESISTOR.

B) AT $t = \infty$, FIND THE VALUES OF THE VARIABLES LISTED IN PART A.

(0 C, 4×10^{-4} A, 0 V, 80 V; 2.4×10^{-2} C, 0 A, 80 V, 0 V)

15.



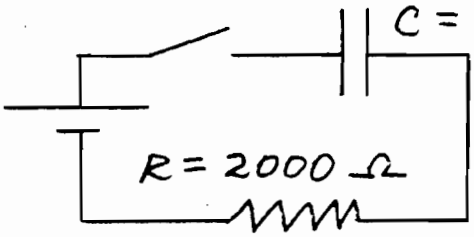
AS WE CLOSE THE SWITCH, WE START OUR CHRONOMETER.

A) AT $t = 0$, FIND THE CURRENT FLOWING THROUGH EACH RESISTOR.

B) AT $t = \infty$, FIND THE CURRENT FLOWING THROUGH EACH RESISTOR AND THE CHARGE STORED BY THE CAPACITOR.

C) AT $t = .02$ SECONDS, FIND THE CHARGE STORED BY THE CAPACITOR, THE CURRENT FLOWING THROUGH EACH RESISTOR AND THE VOLTAGE DROPS ACROSS EACH DEVICE.

(12 A, 3 A; 0 A, 3 A, .96 C; .21235 C, 9.3456 A, 3 A, 106.2 V, 373.8 V, 480 V)

16. 

AT $t = 0$, WE CLOSE THE SWITCH.

A) FIND THE TIME FOR THE CURRENT TO DROP TO $\frac{1}{e}$ th, THAT IS 36.79%, OF ITS INITIAL VALUE.

B) FIND THE TIME FOR THE CAPACITOR TO BECOME 90% FULL OF CHARGE.

(8 SEC, 18.42 SEC)

17. REFER BACK TO PROBLEM 13 B. THE TIME IS 15 SECONDS AFTER CLOSING THE SWITCH. FIND THE:

A) POWER DELIVERED TO THE CAPACITOR. (5.513×10^{-3} W)

B) POWER DELIVERED TO THE RESISTOR. (1.941×10^{-2} W)

C) POWER SUPPLIED BY THE BATTERY. (2.492×10^{-2} W)