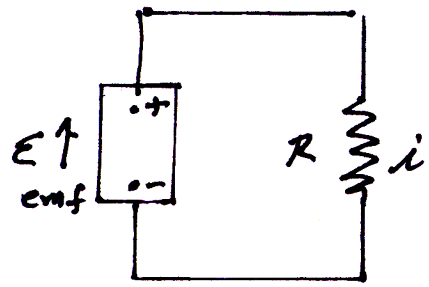
CIRCUITS



WORK IS REQUIRED TO MOVE A CHG FROM THE LOWER POTENTIAL AT − TO THE HIGHER POTENTIAL AT + VOLTAGE IN THE BATTERY

$$\mathcal{E} = \frac{dW}{dq}$$

$$dW = \mathcal{E} dq = \mathcal{E} i dt = P dt$$

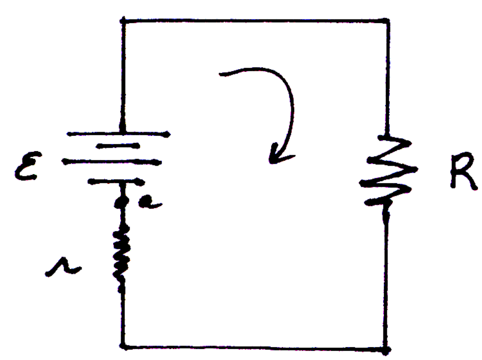
VOLTAGE METHOD

KIRCHOFF'S LAW $\sum_{\text{closed loop}} V = 0$

OHM'S LAW

$V = iR$

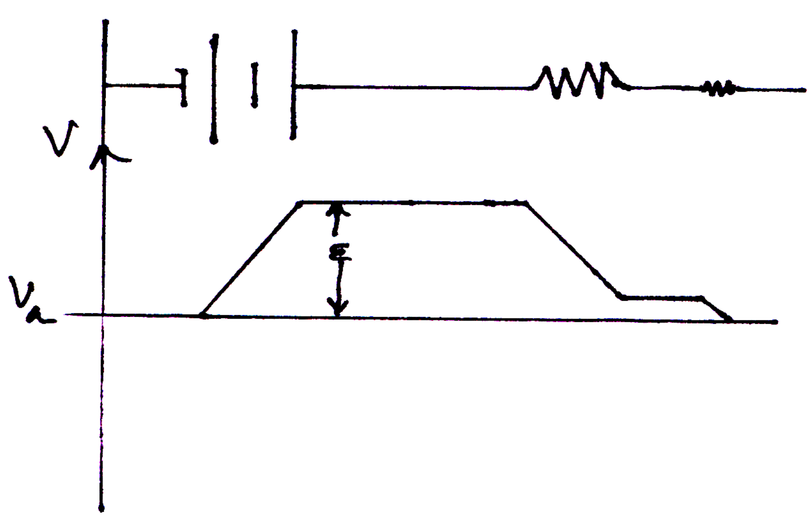
JUNCTION EQUATION $\sum i_{in} = \sum i_{out}$



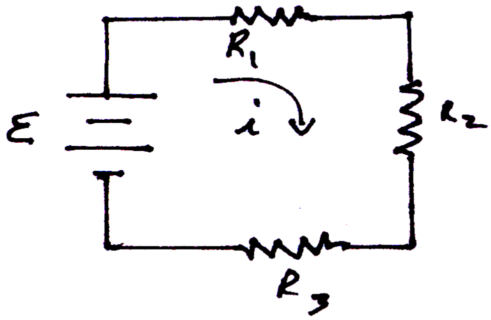
$$\sum_{\text{loop}} V = 0$$

$$\mathcal{E} - iR - ir = 0$$

$$i = \frac{\mathcal{E}}{R + r}$$



SERIES RESISTORS



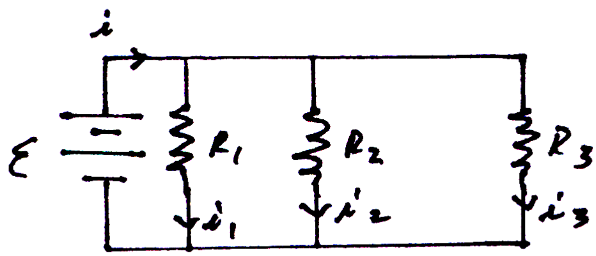
$$\sum V_{loop} = 0$$

$$\mathcal{E} - iR_1 - iR_2 - iR_3 = 0$$

$$\mathcal{E} = i(R_1 + R_2 + R_3) = 0$$

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

PARALLEL RESISTORS



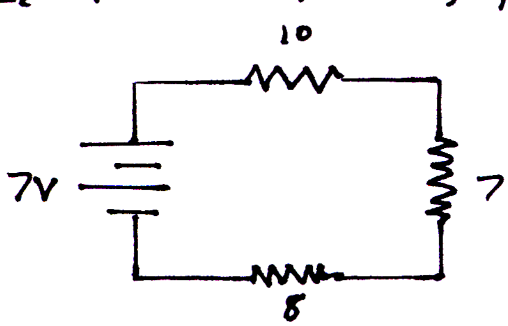
$$\mathcal{E} - i_1 R_1 = 0 \qquad \mathcal{E} - i_2 R_2 = 0 \qquad \mathcal{E} - i_3 R_3 = 0$$

$$i = i_1 + i_2 + i_3 = \frac{\mathcal{E}}{R_1} + \frac{\mathcal{E}}{R_2} + \frac{\mathcal{E}}{R_3} = \frac{\mathcal{E}}{R_{eq}}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \qquad \frac{1}{R_{eq}} = \sum \frac{1}{R_i}$$

FOR 2 RESISTORS $R_{eq} = \dfrac{R_1 \times R_2}{R_1 + R_2}$

pLE 1 Find i, V_{10}, V_7, V_8



$$i = \frac{\mathcal{E}}{R} = \frac{7}{10+8+7} = \frac{7}{25} = 0.28\,A$$

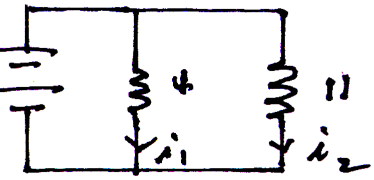
$V_{10} = 10(.28) = 2.8$

$V_7 = 7(.28)$ 1.96

$V_8 = 8(.28)$ 2.24

7 VOLTS

II



find i, i_1, i_2, V_4, V_{11}

$$\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{11} = \frac{4 \times 11}{4+11} = 2.93\ A$$

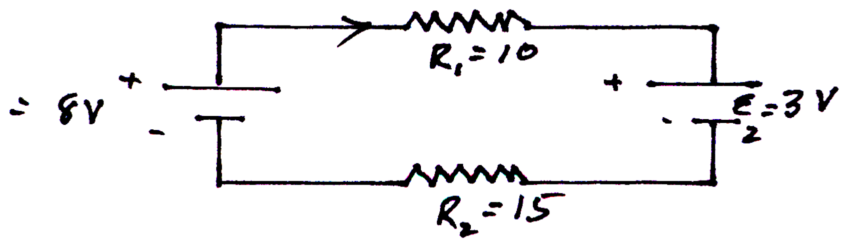
$$i = \frac{\varepsilon}{R_{eq}} = \frac{9}{2.93} = 3.07A$$

$$i_1 = \frac{\varepsilon}{R_1} = \frac{9}{4} = 2.25 \qquad V_4 = 9V$$

$$i_2 = \frac{\varepsilon}{R_2} = \frac{9}{11} = .818 \qquad V_{11} = 9V$$

MULTIPLE BATTERIES

LE III



FIND

$i, P_{\varepsilon_1}, P_{\varepsilon_2}, P_{R_1}, P_{R_2}$

$$\sum V_{Loop} = 0 \qquad +\varepsilon_1 - iR_1 - \varepsilon_2 - iR_2 = 0$$

$$\varepsilon_1 - \varepsilon_2 = i(R_1 + R_2) = i(10+15) = 25i$$

$$i = \frac{\varepsilon_1 - \varepsilon_2}{25} = \frac{8-3}{25} = 0.2\ A$$

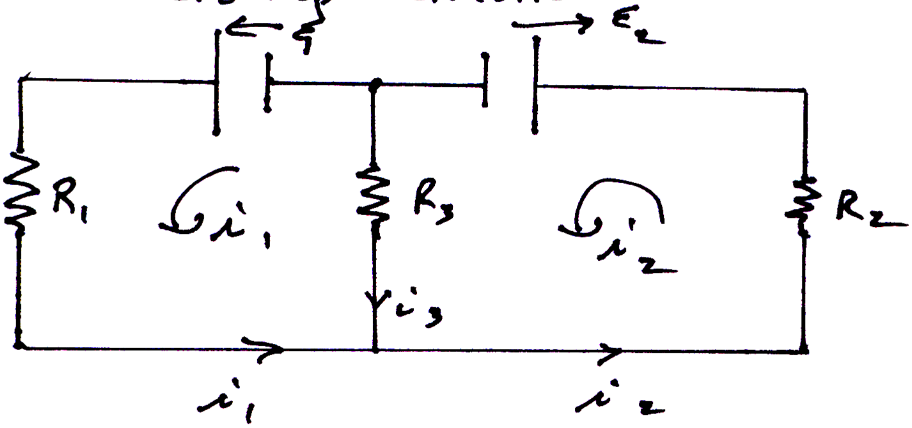
$$= \varepsilon_1 i = 8(.2) = 1.6\,W \qquad P_{R_1} = i^2 R_1 = (0.2)^2(10) = 0.4\,W$$

$$= \varepsilon_2 i = 3(.2) = .6\,W \qquad P_{R_2} = i^2 R_2 = (0.2)^2(15) = 0.6\,W$$

$$P_{\varepsilon_1} = P_{\varepsilon_2} + P_{R_1} + P_{R_2}$$

$$1.6 = +0.6 + 0.4 + 0.6 = 1.6$$

MULTI LOOP CIRCUITS



$\sum i_{in} = \sum i_{OUT}$

$i_1 + i_3 = i_2$

UNKNOWNS i_1 i_2 i_3 EQUATIONS $i_1 + i_3 = i_2$

WE NEED TWO MORE EQUATIONS

$\mathcal{E}_1 - i_1 R_1 + i_3 R_3 = 0$ $-i_3 R_3 - i_2 R_2 - \mathcal{E}_2 = 0$

$\mathcal{E}_1 - i_1 R_1 + R_3 (i_2 - i_1) = 0$ $-R_3 (i_2 - i_1) - i_2 R_2 - \mathcal{E}_2 = 0$ (2)

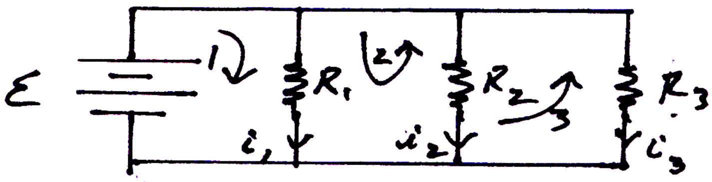
2 EQUATIONS IN TWO UNKNOWNS i_1 & i_2

MPLE I $R_1 = 3 \quad R_2 = 8 \quad R_3 = 6 \quad \mathcal{E} = 12$

the

ts

i_3



$\mathcal{E} - i_1 R_1 = 0 \qquad i_1 = \frac{\mathcal{E}}{R_1} = \frac{12}{3} = 4A$

2 $\quad -i_1 R_1 + i_2 R_2 = 0 \qquad i_2 = i_1 \left(\frac{R_1}{R_2}\right) = 4\left(\frac{3}{8}\right) = 1.5A$

3 $\quad -i_2 R_2 + i_3 R_3 = 0 \qquad i_3 = i_2 \left(\frac{R_2}{R_3}\right) = 1.5\left(\frac{8}{6}\right) = 2A$

$i = i_1 + i_2 + i_3 = 4 + 1.5 + 2 = 7.5A$

$V_{R_1} = i_1 R_1 = 4(3) = 12V$

$V_{R_2} = i_2 R_2 = 1.5(8) = 12V$

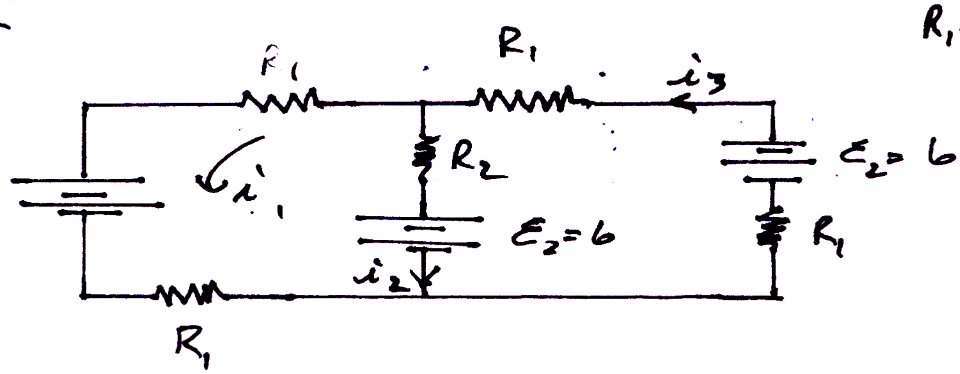
$V_{R3} = i_3 R_3 = 2(6) = 12V$

PLE II $\qquad R_1 = 2 \quad R_2 = 4$

FOR

e

i_3



JUNCTION RULE $\quad i_3 = i_1 + i_2$

Loop $\quad -i_1 R_1 - \mathcal{E}_1 - i_1 R_1 + \mathcal{E}_2 + i_2 R_2 = 0$

$-2i_1(2) - 3 + 6 + i_2(4) = 0$

$\boxed{-4i_1 + 4i_2 = 3}$ ①

Loop

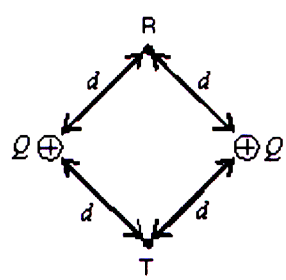
$-i_3 R_1 + \cancel{\mathcal{E}_2} - i_3 R_1 - i_2 R_2 - \cancel{\mathcal{E}_2} = 0$

$\boxed{2i_3(2) - i_2(4) = 0}$ ② $\qquad i_1 = \frac{1}{2} \quad i_2 = -\frac{1}{4} \quad i_3 = \frac{1}{4}$

Phys 121 Sample Quiz 2

1. A 5.5×10^{-8}-C charge is fixed at the origin. A -2.3×10^{-8}-C charge is moved from $x = 3.5$ cm on the x axis to $y = 3.5$ cm on the y axis. The change in potential energy of the two-charge system is:
A) 3.2×10^{-4} J
B) -3.2×10^{-4} J
C) 9.3×10^{-3} J
D) -9.3×10^{-3} J
E) 0

2. Points R and T are each a distance d from each of two equal positive charges as shown. If $k = 1/4\pi\epsilon_0$, the work required to move a test charge q from R to T is:



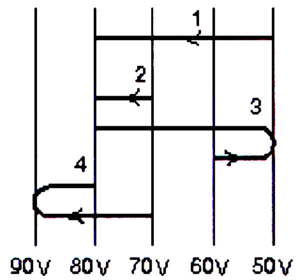
A) 0
B) kQq/d^2
C) kQq/d
D) $kqQ/(\sqrt{2}d)$
E) $kQq/(2d)$

3. Two large parallel conducting plates are separated by a distance d, placed in a vacuum, and connected to a source of potential difference V. An oxygen ion, with charge $2e$, starts from rest on the surface of one plate and accelerates to the other. If e denotes the magnitude of the electron charge, the final kinetic energy of this ion is:
A) $eV/2$
B) eV/d
C) eVd
D) Vd/e
E) $2eV$

4. Two conducting spheres are far apart. The smaller sphere carries a total charge of
6×10^{-8} C. The larger sphere has a radius that is twice that of the smaller and is neutral. After the two spheres are connected by a conducting wire, the charges on the smaller and larger spheres, respectively, are:
A) 4×10^{-8} C and 2×10^{-8} C
B) 2×10^{-8} C and 4×10^{-8} C
C) -6×10^{-8} C and 12×10^{-8} C
D) 6×10^{-8} C and 0
E) 3×10^{-8} C and 3×10^{-8} C

5. A metal sphere carries a charge of 5×10^{-9} C and is at a potential of 400 V, relative to the potential far away. The potential at the center of the sphere is:
A) 400 V
B) –400 V
C) 2×10^{-6} V
D) 0
E) none of these

6. An electron goes from one equipotential surface to another along one of the four paths shown below. Rank the paths according to the work done by the electric field, from least to greatest.

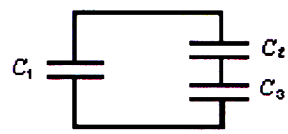


A) 1, 2, 3, 4
B) 4, 3, 2, 1
C) 1, 3, 4 and 2 tie
D) 4 and 2 tie, then 3, then 1
E) 4, 3, 1, 2

7. Pulling the plates of an isolated charged capacitor apart:
A) increases the capacitance
B) increases the potential difference
C) does not affect the potential difference
D) decreases the potential difference
E) does not affect the capacitance

8. A 2-μF and a 1-μF capacitor are connected in series and a potential difference is applied across the combination. The 2-μF capacitor has:
A) twice the charge of the 1-μF capacitor
B) half the charge of the 1-μF capacitor
C) twice the potential difference of the 1-μF capacitor
D) half the potential difference of the 1-μF capacitor
E) none of the above

9. Capacitor C_1 is connected alone to a battery and charged until the magnitude of the charge on each plate is q_0. Then it is removed from the battery and connected to two other capacitors C_2 and C_3 as shown. The final charges on the capacitors are related by:



A) $q_0 = q_1 + q_2 + q_3$
B) $q_1 + q_2 + q_3 = 0$
C) $q_0 = q_1, q_2 + q_3 = 0$
D) $q_0 = q_1 + q_2, q_2 = q_3$
E) $q_0 = q_2 + q_3, q_1 = 0$

10. Capacitors A and B are identical. Capacitor A is charged so it stores 4 J of energy and capacitor B is uncharged. The capacitors are then connected in parallel. The total stored energy in the capacitors is now:
A) 16 J
B) 8 J
C) 4 J
D) 2 J
E) 1 J

11. Suppose one has available:

    two sheets of copper

    a sheet of mica (thickness = 0.1 mm, $\kappa = 6$)

    a sheet of glass (thickness = 2 mm, $\kappa = 7$)

    a slab of paraffin (thickness = 1 cm, $\kappa = 2$)

    To obtain the largest capacitance, place between the two copper sheets:

    A) a 1 mm gap of air
    B) the mica
    C) the glass
    D) the paraffin
    E) the mica, glass, and paraffin

12. The current is zero in a conductor when no potential difference is applied because:

    A) the electrons are not moving
    B) the electrons are not moving fast enough
    C) for every electron with a given velocity there is another with a velocity of equal magnitude and opposite direction
    D) equal numbers of electrons and protons are moving together
    E) otherwise Ohm's law would not be valid

13. Five cylindrical wires are made of the same material. Their lengths and radii are

wire 1: length ℓ, radius r
wire 2: lenth $3\ell/2$, radius $r/2$
wire 3: length $\ell/2$, radius $r/2$
wire 4: length ℓ, radius $r/2$
wire 5: length 2ℓ, radius $r/2$

Rank the wires according to their resistances, least to greatest.

A) 1, 2, 3, 4, 5
B) 5, 4, 3, 2, 1
C) 1 and 2 tie, then 5, 3, 4
D) 1, 3, 4, 2, 5
E) 1, 2, 4, 3, 5

14. You wish to double the rate of energy dissipation in a heating device. You could:

A) double the potential difference keeping the resistance the same
B) double the current keeping the resistance the same
C) double the resistance keeping the potential difference the same
D) double the resistance keeping the current the same
E) double both the potential difference and current

15. It is better to send 10,000 kW of electric power long distances at 10,000 V rather than at 220 V because:

A) there is less heating in the transmission wires
B) the resistance of the wires is less at high voltages
C) more current is transmitted at high voltages
D) the insulation is more effective at high voltages
E) the iR drop along the wires is greater at high voltage

Answer Key

1. E
2. A
3. E
4. B
5. A
6. D
7. B
8. D
9. D
10. D
11. B
12. C
13. D
14. D
15. A