Capacitor and Dielectric

1. A 6 μF capacitor is connected in series with a 4μF capacitor, a potential difference of 200V is applied across the pair (a) calculate the equivalent capacitance (b) what is the charge on each capacitor
   (c) what is the potential difference across each capacitor?
   (Ans: (a) 2.4μF (b) 480μC (c) $V_6 = 80V$ $V_4 = 120V$)
2. A parallel plate capacitor has circular plates of 8.22cm radius and 1.31mm separation (a) calculate the capacitance (b) what charge will appear on the plates if a potential difference of 116V is applied? (Ans: (a) 143pF (b) 1.66×10^{-8} C)
3. A 32 μF capacitor is connected across a programmed power supply. During the interval from t = 0 to t = 3s the output voltage of the supply is given by $V(t) = 6 + 4t - 2t^2$ volts. At t = 0. 5 s find (a) the charge on the capacitor, (b) the current into the capacitor, and (c) the power output from the power supply.(Ans: (a) 240μC (b) 64μA (c) 480μ W)
4. A parallel plate capacitor has plate with dimensions 3cm x 4cm separated by 2mm. The plates are connected across a 60 V battery. Find (a) the capacitance (b) the magnitude of the charge on each plate. (Ans: (a) 5,31 pF (b) 3.19×10^{-10} C)
5. In figure-1 find the equivalent capacitance of the combination. Assume that C1 = 10.3 μ F, C2= 4.8 μ F and C3 = 3.9 μ F.(Ans:
6. For the circuit in figure-2 find: (a) the equivalent capacitance (b) the charge and potential difference for each capacitor.(Ans: (a) 2VμF (b) V1=16V, V4=8V ,V2= V3=24V)

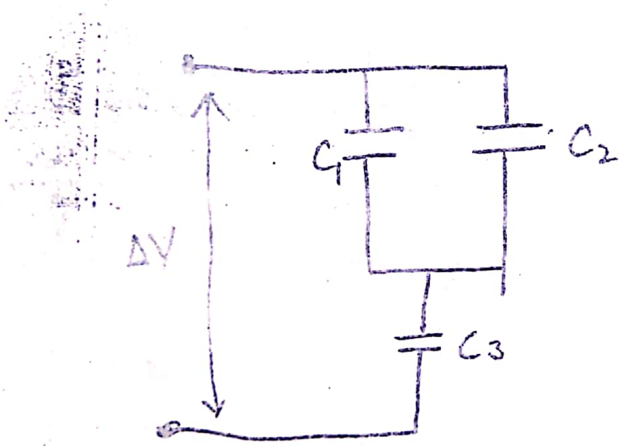

fig # 1

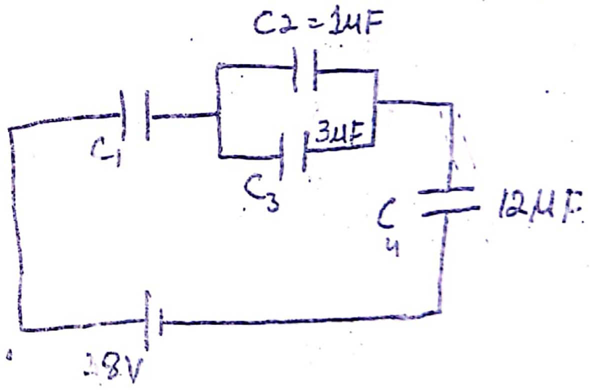

fig # 2

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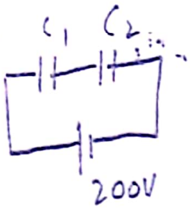
$C_{eq} = 2.4\mu C \quad = \dfrac{C_1 C_2}{C_1 + C_2}$

$Q = CV = 480\mu C = q_1 = q_2$



For $6\mu F$:

$V_6 = \dfrac{q}{C_6} = 80$

$V_4 = V - V_6 = 200 - 80 = 120V$

Q.2 $C = \dfrac{\epsilon_0 A}{d} = 143pF$

$q = CV = 1.66 \times 10^{-8} C$

Q.3 $V_{at}(0.5) = 7.5V$

$q = CV = 32 \times 10^{-6}(7.5) = 2.4 \times 10^{-4} C = 240\mu C$

$i = \dfrac{dq}{dt} = C\dfrac{dV}{dt} = 32\mu F(2) = 64\mu A$

$\left(\dfrac{dV}{dt} = 4 - 4t \quad t = 0.5 \quad = 2\right)$

$P = iV = 64 \times 10^{-6}(7.5) = 480\mu W$

Q.4

$C = \dfrac{\epsilon_0 A}{d}$

$= 8.8 \times 10^{-12} \times (1.2 \times 10^{-3}) / 2 \times 10^{-3}$

$C = 5.31 pF$

$Q = CV = 5.3 \times 10^{-12}(60)$

$Q = 3.19 \times 10^{-10} C$

Q.5 $C_{12} = C_1 + C_2 = 10.3 + 4.8 = 15.1$

$C_{eq} = \dfrac{C_{12} C_3}{C_{12} + C_3} = 3.09\mu C$

Q.6 $C_2 + C_3 = C_{23} = 4\mu F$

$\dfrac{1}{C_{eq}} = \dfrac{1}{4\mu F} + \dfrac{1}{6\mu F} + \dfrac{1}{12\mu F} \Rightarrow C_{eq} = 2\mu F$

(b) since

$q_1 = q_2 + q_3 = q_4 = Q$

$Q = C_{eq} V = 2\mu F(48) = 96\mu C$

$q_1 = q_4 = 96\mu C$

$V_1 = \dfrac{Q_1}{C_1} = \dfrac{96\mu}{6\mu} = 16V$

$V_4 = \dfrac{Q_4}{C_4} = \dfrac{96\mu}{12\mu} = 8V$

$V_2 = V_3 = 48 - (16 + 8) = 24V$

$Q_2 = C_2 V_2 = 1\mu(24) = 24\mu C$

$Q_3 = C_3 V_3 = 3\mu F(24) = 72\mu C$

$(Q_2 + Q_3 = 96\mu C$ Not$)$

Current and Resistance

Q.1: Suppose that the material composing a fuse melts once the current density rises to $440 A/cm^2$. What diameter of cylinder wire should be used for the fuse to limit the current to 0.552A?

Q.2: How long does it take electrons to get from a car battery to the starting motor? Assume that the current is 115A and the electrons travel through copper wire with cross-sectional area $31.2 mm^2$ and length 85.5cm .($n = 8.49 \times 10^{28}\ m^{-3}$)

Q.3: A fluid with resistivity $9.4\ \Omega\,m$ seeps into the space between the plates of a 110pF parallel plate air capacitor. When the space is completely filled, what is the resistance between the plates?($\varepsilon_0 = 8.85$ pF/m)

Q.4: For a hypothetical electronic device, the potential difference V in volts, measured across the device, is related to the current "i" in mA by $V = 3.55 i^2$. (a) find the resistance when current is 2.4mA. (b) At what value of the current is the resistance equal to $16\ \Omega$?

Q.5: A student's 9V , 7.5 W portable radio was left on from 9:00p.m until 3:00 am .How much charge passed through the wires?

Q.6: A 32 µF capacitor is connected across a programmed power supply. During the interval from t = 0 to t = 3s the output voltage of the supply is given by $V(t) = 6 + 4t - 2t^2$ volts. At t = 0.5 s find (a) the charge on the capacitor, (b) the current into the capacitor, and (c) the power output from the power supply.

Solution

Current and Resistance

Q1 $J = 440\ A/cm^2$; $I = 0.552\ A$

$d = ?$

$$A = \frac{I}{J} = \frac{0.552}{440}$$

$$\pi r^2 = 1.25 \times 10^{-3}$$

$$d^2 = \frac{4\,(1.25 \times 10^{-3})}{3.142}$$

$$\boxed{d = 0.0399\ cm}$$ Ans.

Q2 $I = 115\ A$; $n = 8.49 \times 10^{28}\ m^{-3}$

$L = 85.5\ cm = 0.855\ m$; $A = 31.2\ m^3$

$t = ?$

$$t = \frac{q}{I} = \frac{nALe}{I} = \frac{(8.49 \times 10^{28})(31.2)(0.855)(1.6 \times 10^{-19})}{115}$$

$$\boxed{t = 3151 \times 10^{9}\ sec}$$ Ans.

Q3 $\rho = 9.4\ \Omega m$; $C = 110 \times 10^{-12}\ F$; $\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$

$R = ?$

$$\rho = \frac{RA}{d} \quad ; \quad C = \frac{A\varepsilon_0}{d}$$

$$9.4 = R\,(1.24 \times 10^{-23}) \quad ; \quad \frac{A}{d} = \frac{C}{\varepsilon_0}$$

$$R = \frac{9.4}{1.24 \times 10^{-23}} \quad ; \quad \frac{A}{d} = \frac{110 \times 10^{-12}}{8.85 \times 10^{12}}$$

$$\frac{A}{d} = 1.24 \times 10^{-23}$$

$$\boxed{R = 7.5 \times 10^{23}}\ \Omega$$

Ans.

Q4 $V = 3.55\, i^2$ (6)

(a) $R = ?$; $i = 2.4\, mA = 2.4 \times 10^{-3} A$

(b) $i = ?$; $R = 16\,\Omega$

(a) $V = iR$

$3.55\, i^{\cancel{2}} = \cancel{i} R$

$3.55\,(2.4 \times 10^{-3}) = R$

$\boxed{R = 8.52 \times 10^{-3}\,\Omega}$ Ans (a)

(b) $V = i R$

$0.355\, i^2 = \cancel{i}\,(16)$ (b)

$i = \dfrac{16}{0.355}$

$\boxed{i = 45.07\, A}$ Ans

Q5 $P = 7.5\, W$; $V = 9V$ (c)

$t = 6 \times 60 \times 60 = 21600$

$P = IV$; $I = \dfrac{P}{V}$

$I = \dfrac{7.5}{9} \Rightarrow 0.8333$

$q = It$

$q = (0.8333)(21600)$

$\boxed{q = 18000\, C}$ Ans.

Q.6

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Q7 $C = 32\,\mu F = 32\times10^{-6}\,F$

$V(t) = 6+4t-2t^2$; $t = 0.5$ sec

(a) $q = ?$ (b) $I = ?$ (c) $P = ?$

$V(0.5) = 6+4(0.5)-2(0.5)^2$

$V = 7.5\,V$

(a) $q = CV = (32\times10^{-6})(7.5)$

$\boxed{q = 2.4\times10^{-4}\,C}$ Ans.

(b) $I = \dfrac{q}{t} = \dfrac{2.4\times10^{-4}}{0.5}$

$\boxed{I = 4.8\times10^{-4}}$ Ans.

(c) $P = IV = (4.8\times10^{-4})(7.5)$

$\boxed{P = 3.6\times10^{-3}\,W}$ Ans.

Magnetic Field

Q1. $B = 83\times10^{-3}\,T$; $v = 7.2\times10^{6}\,m/s$

(a) $\theta = 90^\circ$; $F = ?$

(b) $a = 4.4\times10^{6}\,m/s^2$; $\theta = ?$

$F = evB\sin\theta$

(a) $F = (1.6\times10^{-19})(7.2\times10^{6})(83\times10^{-3})\sin 90$

$\boxed{F = 9.5616\times10^{-14}\,N}$ Ans.

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