National University of Computer and Emerging Sciences

FAST LAHOREFALL 2021

Assignment # 3 | **Applied Physics** | **Max. Marks: 50**

Section: BCS 1B | **Submission Date:** | **30th December, 2021 (Thu)**

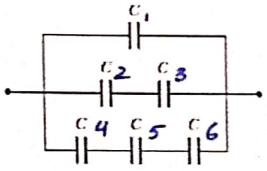
Instructions:

1. *Solve the assignment questions in the space provided.*
2. *Assignment should be hand-written. Typed assignment will not be accepted.*
3. *Make diagrams/illustrations wherever possible.*

ROLL NO.: 21L-5294 **NAME:** Muhammad Laraib Akhtar

Question #1: Evaluate the equivalent capacitance of the configuration shown in Figure. All the capacitors are identical, and each has capacitance ***C*?**

(5)



Answer:

$\frac{1}{C_{eq}} = \frac{1}{C_2} + \frac{1}{C_3}$ $\frac{1}{C_{eq}} = \frac{1}{C_4} + \frac{1}{C_5} + \frac{1}{C_6}$ $\frac{1}{C_{eq}} = \frac{1}{C_1}$

$C_{eq} = \frac{C}{2}$ $C_{eq} = \frac{C}{3}$ $C_{eq} = C$

$C_{total} = C + \frac{C}{2} + \frac{C}{3}$

$$C = \frac{11}{6} C$$

Question #2: Two capacitors when connected in parallel give an equivalent capacitance of 9.00 pF and give an equivalent capacitance of 2.00 pF when connected in series. What is the capacitance of each capacitor?

(5)

Answer:

$9pF = C_1 + C_2$ $\frac{1}{2} = \frac{1}{C_1} + \frac{1}{C_2}$

$2pF = \frac{C_1 C_2}{C_2 + C_1}$

$C_1 = 9pF - C_2$

$$2pF = \frac{(9pF - C_2)(C_2)}{C_2 + 9 - C_2}$$

$$18pF = 9C_2 - C_2^2$$

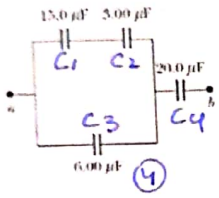
$$C_2^2 - 9C_2 + 18pF = 0$$

$$(C_2 - 6pF)(C_2 - 3pF) = 0$$

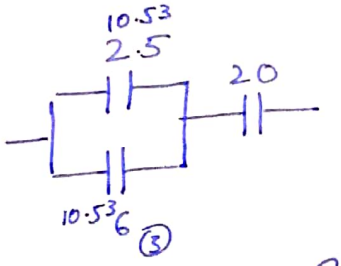
$C_2 = 6pF$ $\quad C_1 = 3pF$

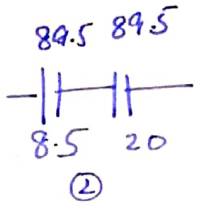
Question #3: Four capacitors are connected as shown in Figure. **(a)** Find the equivalent capacitance between points *a* and *b*. **(b)** Calculate the charge on each capacitor if ΔV_{ab} = 15.0 V.

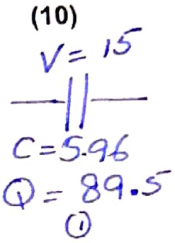
(10)



④







Answer:

$$\frac{1}{C_{eq}} = \frac{1}{15\mu F} + \frac{1}{3\mu F}$$

$$C_{eq} = \frac{5}{2}\mu F$$

$$C_{eq} = 2.5\mu F$$

$$C = (2.5 + 6)\mu F$$

$$C = 8.5\mu F$$

$$\frac{1}{C_{eq}} = \frac{1}{8.5\mu F} + \frac{1}{20\mu F}$$

$$C_{eq} = \frac{340}{57}\mu F$$

$$C_{eq} = 5.96\mu F$$

① $C = 5.96\mu F$
$V = 15V$
$Q = 89.5\mu C$

② $C_4 = 20\mu F$ $\quad C = 8.5\mu F$
$V_4 = 4.475$ $\quad V = 10.53$
$Q_4 = 89.5$ $\quad Q = 89.5$

③ $C = 2.5\mu F$ $\quad C_3 = 6\mu F$
$V = 10.53\ V$ $\quad V_3 = 10.53\ V$
$Q = 26.3\mu C$ $\quad Q_3 = 63.1\mu C$

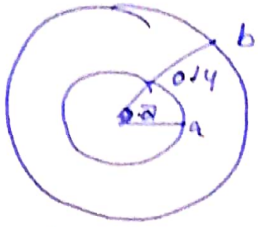
④ $C_1 = 15\mu F$ $\quad C_2 = 3\mu F$
$V_1 =$ ~~0.93~~ $\quad V_2 =$ ~~8.51~~ V_3
$Q_1 =$ ~~26.3~~ μC $\quad Q_2 =$ ~~26.3~~ μC

$Q_1 = 26.3\mu C$
$Q_2 = 26.3\mu C$
$Q_3 = 63.1\mu C$
$Q_4 = 89.5\mu C$

Question #4: An air-filled spherical capacitor is constructed with inner and outer shell radii of 7.00 and 14.0 cm, respectively. **(a)** Calculate the capacitance of the device. **(b)** What potential difference between the spheres results in a charge of 4.00 μC on the capacitor?

(10)

Answer:



$$C = 4\pi\varepsilon_0\left(\frac{ab}{b-a}\right)$$

$$C = 4 \times 3.14 \times 8.85 \times 10^{-12}\left(\frac{0.07 \times 0.14}{0.14 - 0.7}\right)$$

$$C = 1.11 \times 10^{-10}\ (0.14)$$

$$C = 1.554 \times 10^{-11}$$

$$C = 0.1554\ pF$$

$$V = \frac{Q}{C}$$

$$V = \frac{4 \times 10^{-6}}{15.54 \times 10^{-12}} \qquad V = 257400\ V$$

$$V = 257.4\ KV$$

Question #5: In a certain particle accelerator, a current of 0.50 mA is carried by a 5.0-MeV proton beam that has a radius equal to 1.5 mm. **(a)** Find the number density of protons in the beam. **(b)** If the beam hits a target, how many protons hit the target in 1.0 s?

(10)

Answer:

$$J = ne\,V_d$$

257400 $\quad K = \frac{1}{2}mv^2$

$$V_d = \sqrt{\frac{2K}{m}}$$

$$V_d = \sqrt{\frac{2 \times 5 \times 1.6 \times 10^{-19} \times 10^6}{1.67 \times 10^{-27}}}$$

$$V_d = 8.1 \times 10^7\ m/s$$

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

$$J = \frac{0.5 \times 10^{-3}}{\pi \times (1.5 \times 10^{-3})^2}$$

$$J = 70.7\ Am^{-2}$$

$$J = neV_d$$

$$n = \frac{J}{eV_d}$$

$$n = \frac{70.7}{1.6\times10^{-19}\times3.1\times10^{7}}$$

$$n = 1.425\times10^{23} \text{ protons/m}^3$$

$\frac{q}{s\,m^2}$ $\frac{d}{m/s}$ $= \frac{1}{m^3}$

$$I = \frac{q}{t}$$

$$q = It$$

$$ne = It$$

$$n = \frac{0.5\times10^{-3}\times1}{1.6\times10^{-19}}$$

$$n = 3.125\times10^{15} \text{ protons.}$$

Question #6: **(a)** Calculate the resistance per unit length of a copper wire has cross-sectional area 2.08 mm^2. **(b)** Find the electric field strength E, when the wire has current equal to 1.3 A. **(10)**

Answer:

$$R = \rho\frac{L}{A}$$

$$\frac{R}{L} = \frac{\rho}{A}$$

$$\frac{R}{L} = \frac{1.77\times10^{-8}\ \Omega m}{(2.08\times10^{-3}\ m)^2}$$

$$\frac{R}{L} = 4.09\times10^{-3}\ \Omega m^{-1}$$

$$E = \frac{V}{d}$$

$$E = \frac{IR}{d}$$

$$E = 1.3\times4.09\times10^{-3}$$

$$E = 5.317\times10^{-3}\ V m^{-1}$$