PH 222-2A

02/26/2022 RECITATION #7

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Ans :- The ~~[illegible]~~ equivalent capacitance of the capacitors when they are connected in parallel combination is as follows :- $C_{eqn} = C_1 + C_2$, where C_1 & C_2 are the capacitance of the capacitor 1 & 2.

The equivalent capacitance of the capacitors when they are connected in series combination is as follows:

$$\frac{1}{C_{eqn}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$C_{eqn} = \frac{C_1 C_2}{C_1 + C_2}$$

The capacitance of the capacitor is :-

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

where Q is the charge on the capacitor and V is the voltage across the capacitor.

The sum of voltage around a closed conducting loop in a circuit must be zero. [∵ Kirchhoff's loop rule]

$$\Sigma V = 0$$

When two capacitors C_1 & C_2 are connected with voltage source V, then voltage across the capacitor C_1 is as follows:-

$$V_{c_1} = \frac{C_2 V}{C_1 + C_2}$$

The voltage across the capacitor C_2 is :- $V_{c_2} = \frac{C_1 V}{C_1 + C_2}$

(a) The capacitors $4\,\mu F$ and $2\,\mu F$ are connected in series when the switch is open. The voltage across the capacitor $C_1 = 4\mu F$ is:-

$$V_{C_1} = \frac{C_2 V}{C_1 + C_2}$$

Substituting $4\mu F$ for C_1, $2\mu F$ for C_2 and $300V$ for V_T we get:-

$$V_{C_1} = \frac{2\mu F}{2\mu F + 4\mu F} \times 300V$$

$$= 100V \qquad \left[\because \frac{2}{6} \times 300\right]$$

The voltage across the capacitor C_2 is:-

$$V_{C_2} = \frac{C_1 V}{C_1 + C_2}$$

Substituting 4 μF for C_1, 2μF for C_2, & 300V for V, we get:-

$$V_{C_2} = \frac{4\mu F}{2\mu F + 4\mu F} \times 300V$$

$$= \underline{\underline{200V}} \qquad \left[\because \frac{\cancel{4}^{2}}{\cancel{6}_{\,2\,1}} \times \cancel{300}^{100} \right]$$

Using Kirchhoff's loop rule to the circuit across the junctions B & D in the figure in the question :-

$$-V_{C_1} - (V_E - V_D) + V_{C_2} = 0$$

$$V_E - V_D = V_{C_2} - V_{C_1}$$

Substituting 100V for V_{C_1} and 200V for V_{C_2}, we get :-

$$V_E - V_D = 200V - 100V$$

$$= \underline{\underline{100V}}$$

$\therefore$ the potential difference $V_E - V_D$ is 100 V

(iv) The capacitor 4 μF and 2 μF are connected in parallel on both sides when the switch is closed.

$$C_{24} = 4\,\mu F + 2\,\mu F$$

$$= 6\,\mu F$$

The voltage across the point E is:

$$V_E = \left(\frac{C_{24}}{C_{24} + C_{24}}\right) V$$

Substituting 6 μF for C_{24} and 300 V for V, we get:-

$$V_E = \left(\frac{6\,\mu F}{6\,\mu F + 6\,\mu F}\right) \times 300\,V$$

$$= 150\,V$$

∴ The potential at point E after switch is closed is 150V.

(ii) The capacitor 4 μF and 2 μF are connected in parallel on both sides, when the switch is closed.

$$C_{24} = 4\,\mu F + 2\,\mu F$$

$$= 6\,\mu F$$

Now, the two capacitors C_{24} are connected in series combination. Hence, their equivalent capacitance is as follows:-

$$C_{eqv} = \frac{C_{24} \cdot C_{24}}{C_{24} + C_{24}}$$

$$= \frac{C_{24}}{2}$$

Substituting 6 μF for C_{24}, we get:-

$$C_{equ} = \frac{\cancel{6}^{3} \mu F}{\cancel{2}\,1} = 3 \mu F$$

The charge passing through the switch is:-

$$Q = C_{equ} \cdot V$$

Substituting 3 μF for C_{equ} and 300V for V, we get:-

$$Q = 3 \mu F \left(\frac{1 F}{10^{6} \mu F} \right) \times 300 V$$

$$= 9 \times 10^{-4} C$$

∴ The charge passing through the switch is $9 \times 10^{-4} C$