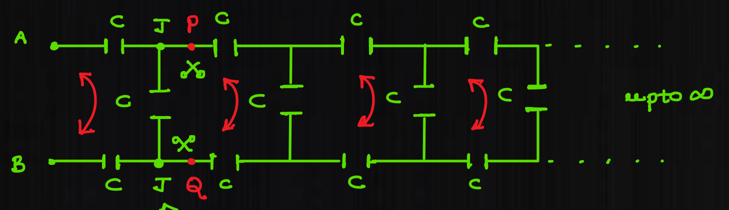
capacitor circuits

21 July 2020 09:58

Q: find the equivalent capacitance b/w points A & B. Each capacitor is of capacity C.



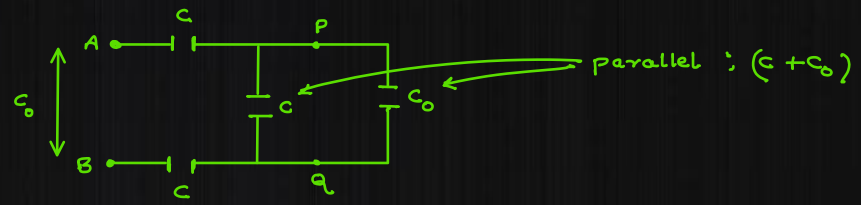
junction (junction is a point of a circuit where more than 3 branches connects each other).

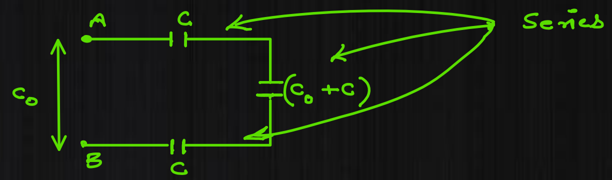
Any junction do not let any two capacitor joined to it in series or parallel combination.

as the pattern of the circuit repeats itself after point P & Q

so we can say the equivalent capacity after points P & Q will be same as it was after A & B.

ie: $(C_{eq})_{AB} = (C_{eq})_{PQ} = C_0$ (Let)





$$\therefore \quad \frac{1}{C_0} = \frac{1}{C} + \frac{1}{C} + \frac{1}{(C_0+C)}$$

$$= \frac{2}{C} + \frac{1}{(C_0+C)}$$

$$\frac{1}{C_0} = \frac{2C_0 + 2C + C}{C(C_0+C)}$$

$$\Rightarrow C C_0 + C^2 = 3C C_0 + 2C_0^2$$

$$\Rightarrow 2C_0^2 + 2C C_0 - C^2 = 0$$

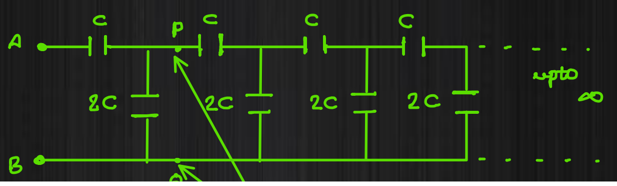
$$\Rightarrow C_0 = \frac{-2C \pm \sqrt{4C^2 + 8C^2}}{2 \times 2}$$

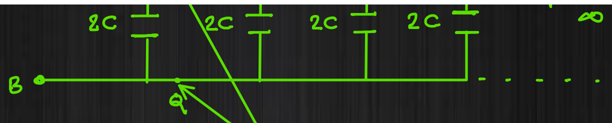
$$\Rightarrow C_0 = \frac{-C \pm C\sqrt{3}}{2}$$

as capacitance cannot be negative :→

$$\therefore C_0 = \frac{C}{2}(\sqrt{3} - 1) \text{ F}$$

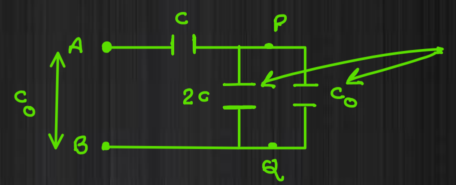
Q: find the equivalent capacitance b/w points A & B.



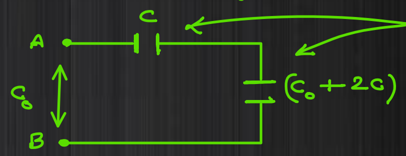


points after which the circuit repeats itself

so $(C_{eq})_{AB} = (C_{eq})_{PQ} = C_0$ (Let)



parallel ; $(C_0 + 2C)$



Series

$$\therefore \frac{1}{C_0} = \frac{1}{C} + \frac{1}{(C_0+2C)}$$

$$\Rightarrow \frac{1}{C_0} = \frac{(C_0+2C+C)}{C(C_0+2C)}$$

$$\Rightarrow C \cdot C_0 + 2C^2 = C_0^2 + 3CC_0$$

$$\Rightarrow C_0^2 + 2CC_0 - 2C^2 = 0$$

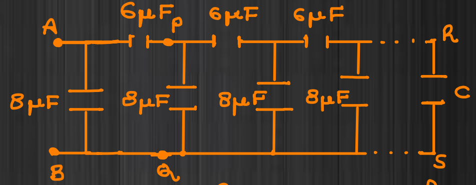
$$C_0 = \frac{-2C \pm \sqrt{4C^2+8C^2}}{2}$$

$$= \frac{-2C \pm \sqrt{12C^2}}{2}$$

$$= -C \pm C\sqrt{3}$$

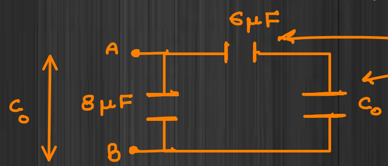
$$\therefore C_0 = C\cdot(\sqrt{3}-1)\ F$$

Q: A finite Ladder is constructed by connecting several sections of $6\mu F$ & $8\mu F$ as shown in the figure. The circuit is terminated by a capacitor of capacity C. find the value of C such that the capacity between A & B becomes independent of the number of sections shown below.

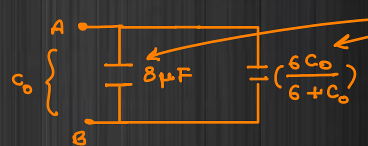


Sol^n: if the equivalent capacitance b/w A & B do not depends upon the no. of capacitors then definitely it must be an infinite Ladder so C must be again the same Ladder before itself

ie; $(C_{eq})_{AB} = (C_{eq})_{PQ} = (C_{eq})_{RS} = C_0$



Series ; $\left(\frac{6 \times C_0}{6+C_0}\right)$



parallel ; $8 + \frac{6C_0}{(6+C_0)}$

so ; $(C_{AB})_{eq} = C_0 = 8 + \frac{6C_0}{(6+C_0)}$

$$\Rightarrow 6C_0 + C_0^2 = 48 + 8C_0 + 6C_0$$

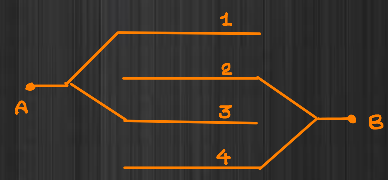
$$\Rightarrow C_0^2 - 8C_0 - 48 = 0$$

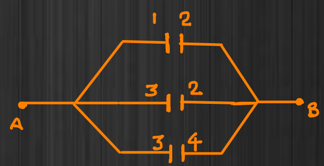
$$\Rightarrow (C_0 - 12)(C_0 + 4) = 0$$

$$\therefore C_0 = 12\,\mu F$$

Ans.

Q: find the equivalent capacitance b/w points A & B, if each plate is of area A m² & gap b/w any two adjacent plates is 'd' m.

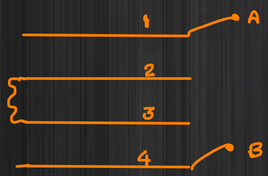




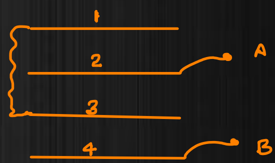
here; $C_{12} = C_{23} = C_{34} = \dfrac{\varepsilon_0 A}{d}$

$$C_{eq} = C_{12} + C_{23} + C_{34} = \frac{3\varepsilon_0 A}{d}$$

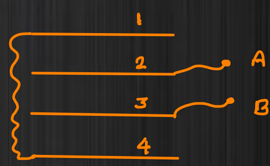
Q: find the equivalent capacitance b/w A & B. Area of each plate is A & gap b/w the plates is d.



i)



ii)



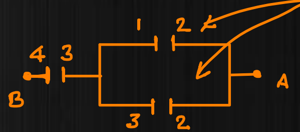
iii)

Solution:→ i)

$C_{12} = C_{34} = \dfrac{\varepsilon A}{d}$ (Both in Series)

so $C_{eq} = \dfrac{\varepsilon A}{2d}$ F

ii)



parallel

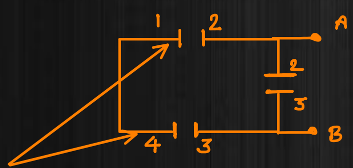
here: $C_{12} = C_{23} = \dfrac{\varepsilon A}{d}$

& $C_{34} = \dfrac{\varepsilon_0 A}{d}$

$$C_{eq} = \frac{C_{34} \times C_{13}}{C_{34} + C_{13}} = \frac{\frac{\varepsilon_0 A}{d} \times \frac{2\varepsilon A}{d}}{\left(\frac{\varepsilon_0 A}{d} + \frac{2\varepsilon A}{d}\right)}$$

$$\therefore C_{eq} = \frac{2\varepsilon_0 A}{3d}\ F$$

iii)



series

$C_{1-4} = \dfrac{\varepsilon A}{2d}$

here; $C_{12} = C_{34} = C_{23} = \dfrac{\varepsilon A}{d}$

C_{23} & C_{1-4} are in parallel

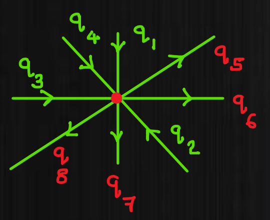
$$\therefore C_{eq} = C_{23} + C_{1-4}$$

$$= \frac{\varepsilon_0 A}{d} + \frac{\varepsilon A}{2d}$$

$$C_{eq} = \frac{3\varepsilon A}{2d}\ F$$

Kirchoff's Laws for capacitor circuits :→ These Laws are used to solve the problems related to capacitor circuits.

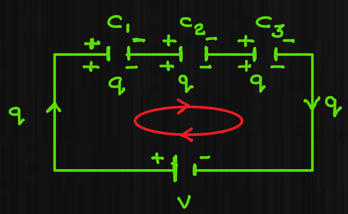
i) Kirchoff's charge Law (KCL) :→ According to this Law the sum of all incoming charges at any junction is always equal to the sum of all outgoing charges. This Law is based upon principle of conservation of charge.



$$\Sigma q_{in} = \Sigma q_{out}$$

$$q_1 + q_2 + q_3 + q_4 = q_5 + q_6 + q_7 + q_8$$

ii) Kirchoff's voltage Law (KVL) :→ According to this Law the total potential difference in any closed loop is equal to zero. It is based upon the principle of conservation of Energy.



Drop across C_1 + Drop across C_2 + Drop across C_3 + Rise across the Battery = 0

$$\left(-\frac{q}{C_1}\right) + \left(-\frac{q}{C_2}\right) + \left(-\frac{q}{C_3}\right) + V = 0$$

$$\Rightarrow V = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3} \quad \text{---} (*)$$

+ → higher Potential

− → Lower Potential

(+) To (−) → potential Drop (−ve change in potential difference)

(−) to (+) → potential Rise (+ve change in potential Difference)