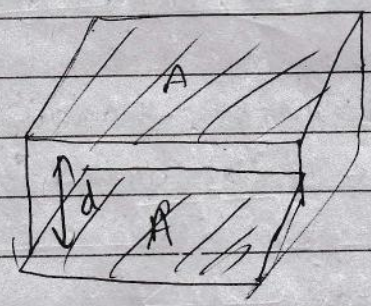
ELECTRIC FIELD...

Capacitance

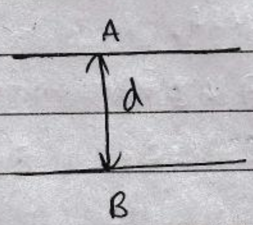
$Q = CV$ → General formula.

$C = 4\pi\varepsilon_0 R$, for an isolated metal sphere.

Capacitance of a parallel plate capacitor



An insulating medium called dielectric is put in the region between the plates such that distance between the plates is equal to thickness of dielectric.



Dielectric thickness $= d$

Permittivity of dielectric $= \varepsilon$

~~Capacitance~~

Area of plates in contact with dielectric $= A$

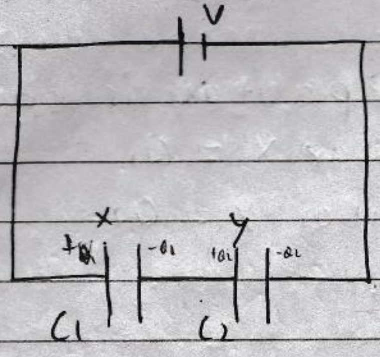
$C = \dfrac{\varepsilon A}{d}$ → capacitance ~~bet.~~ of this apparatus.

In a capacitor, charge in capacitor refers to charge in one of the plates of the capacitor.
This is because net charge is 0 between metal plates.

Lowest permittivity is of vacuum. Thus capacitance is ~~medium~~ max. when dielectric is vacuum.

Capacitors in series

$1/C = 1/C_1 + 1/C_2$



Let C be the equivalent capacitance of C_1 and C_2 in series.
pd across $C_1 = V_1$
pd across $C_2 = V_2$
$V = V_1 + V_2$

$$\frac{Q}{C} = \frac{Q}{C_1} + \frac{Q}{C_2}$$ [By conservation of charge].

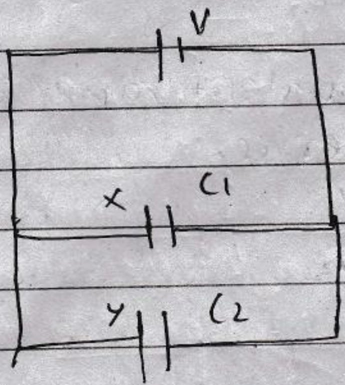
$\therefore 1/C = 1/C_1 + 1/C_2$

Capacitance of a parallel plate capacitor is ~~the capacitance~~ ~~where Q is the char~~ defined as $C = Q/V$, charge per unit potential difference, where Q is the charge in one of the capacitor plates and V is the pd between the plates.
Both capacitors store same charge due to conservation of charge/current when in series.

While a number of capacitor are connected in series, effective capacitance is smaller than the individual smallest capacitance.

capacitors in parallel

$C = C_1 + C_2$



Pd across both capacitors is same.
Charge in capacitor X = Q_1
Charge in capacitor Y = Q_2
$Q = Q_1 + Q_2$
$CV = C_1V + C_2V$
$\therefore C = C_1 + C_2$

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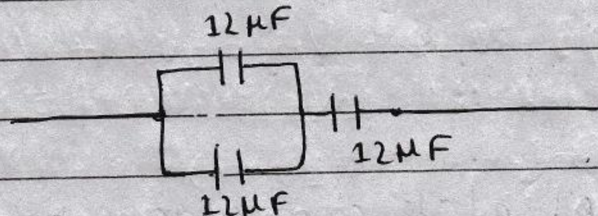
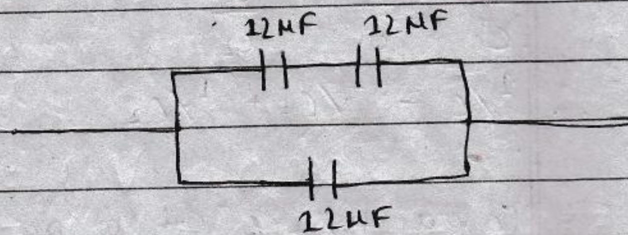


$C = 8\,\mu F$



$C = 18\,\mu F$

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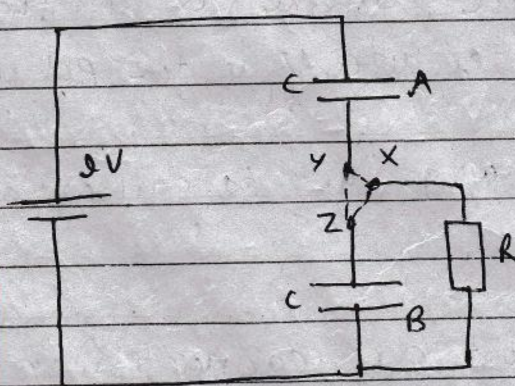
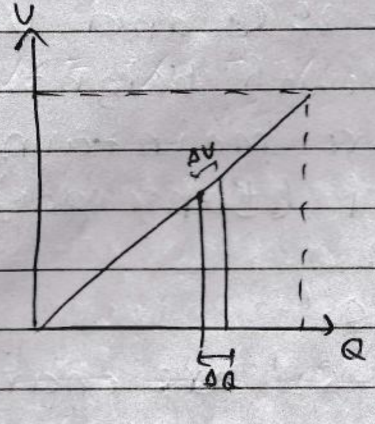


when X and Y are connected, pd across A is 9V
when ~~X~~ Y and Z are connected, pd across A is 4.5 V – case I
Immediately after case I if YZ is disconnected and XZ is connected capacitor discharges and pd across R is 4.5 V.

Energy stored in a charged capacitor



$Q = CV$

$V = \frac{1}{C} Q$

Charge in capacitor plate (initial) = 0

Initial pd between plates of capacitor =

when we go on adding charge to the capacitor ~~at~~, the p d between two plat

also goes on increasing linearly.

Work done in delivering a charge Q to the capacitor plate

= charge x pd

$= Q \times V/2$ (V_{avg})

$= \frac{1}{2} QV$

Final charge in capacitor = Q

Final pd betw the plates = V

The final charge (Q) is transferred to the plate of the capacit

at an average pd. of $\frac{0+V}{2}$. i.e the capacitor is charge

at an avg. potential of $V/2$.

$\therefore U = \frac{1}{2} QV, \frac{1}{2} CV^2, \frac{1}{2} Q^2/C$

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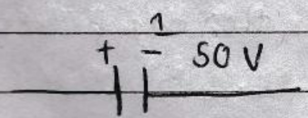
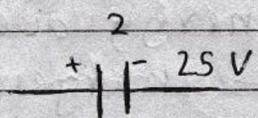


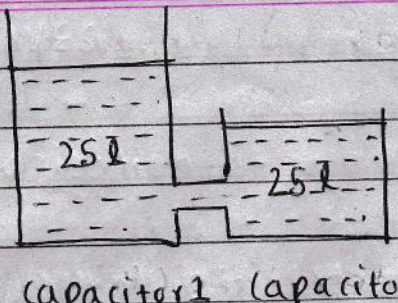
Q = 0.05C



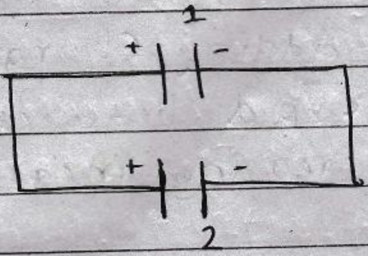
Q = 0.0 5C

Describe th
flow in ch

PTO =)



The case resembel's this case where $Q = 25\,l$ and V is anamolous with height. i.e the capacitors maintain same water level (same pd)



$Q_1 + Q_2 = Q_1' + Q_2'$
where Q_1' and Q_2' are charges in capacitors 1 and 2 after sharing charges.

$C_1V_1 + C_2V_2 = C_1V + C_2V$ [pd will be same]

$\therefore$ ~~Q1~~ $V = \dfrac{C_1V_1 + C_2V_2}{C_1 + C_2}$

$\therefore V = \dfrac{0.05 + 0.05}{3000 \times 10^{-6}}$

$\therefore V = 33.3\ V\ (100/3)$

$\therefore Q_1' = C_1V = 0.033\ C$

$\therefore Q_2' = C_2V = \cancel{0.066\ C}\ 0.067\ C$

$\therefore$ More charge is with more capacitance

Energy before $= \frac{1}{2}C_1V_1^2 + \frac{1}{2}C_2V_2^2 = 1.25 + 0.625 = 1.875\ J$
Energy after $= \frac{1}{2}C_1V^2 + \frac{1}{2}C_2V^2 = 1.667\ J$

When capacitors share charge, charge is conserved but there is loss of energy due to thermal heating and kinetic energy of charges.

Charging and discharging of a capacitor through resistor

Time constant of a RC circuit.

$\tau = RC$

Time that it takes for a capacitor to discharge upto 36.8 % of its original charge stored.

$Q = CV$, $V = Q/C$

Current through Resistor R is $I = -dQ/dt$ and $V = IR$

or $\frac{Q}{C} = -\frac{dQ}{dt} \times R$

or $\int_{Q_0}^{Q} \frac{dQ}{Q} = \int_{0}^{t} \frac{-dt}{CR}$, where Q_0 = initial charge at time 0, Q = final charge at time t

or $[\ln Q]_{Q_0}^{Q} = -\frac{1}{CR}[t]_0^t$

or $\ln Q - \ln Q_0 = -t/CR$

or $\ln(Q/Q_0) = -t/CR$

or $Q/Q_0 = e^{-t/CR}$

$\therefore Q = Q_0 . e^{-t/CR}$, $V = V_0 e^{-t/CR}$, $I = I_0 e^{-t/CR}$

$Q = Q_0 . e^{-t/CR}$

If $t = CR$ --- finding time constant.

$\Rightarrow Q = Q_0 e^{-1}$

$\Rightarrow Q = \frac{1}{e} Q_0$

$\therefore Q = 0.368\, Q_0$

36.8 % of original charge.

Physics