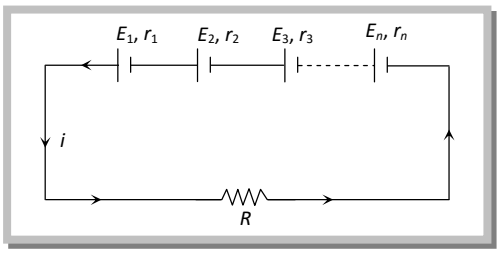
Grouping of cell.

Group of cell is called a battery.

(1) Series grouping: In series grouping anode of one cell is connected to cathode of other cell and so on.

(i) n identical cells are connected in series

(a) Equivalent emf of the combination $E_{eq} = nE$



(b) Equivalent internal resistance $r_{eq} = nr$

(c) Main current = Current from each cell $= i = \dfrac{nE}{R + nr}$

(d) Potential difference across external resistance $V = iR$

(e) Potential difference across each cell $V' = \dfrac{V}{n}$

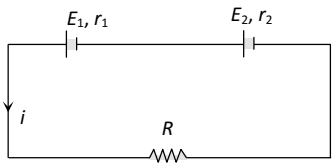
(f) Power dissipated in the circuit $P = \left(\dfrac{nE}{R + nr}\right)^2 . R$

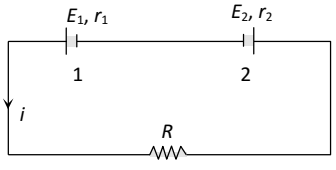
(g) Condition for maximum power $R = nr$ and $P_{\max} = n\left(\dfrac{E^2}{4r}\right)$

(h) This type of combination is used when nr << R.

(ii) If non-identical cell are connected in series

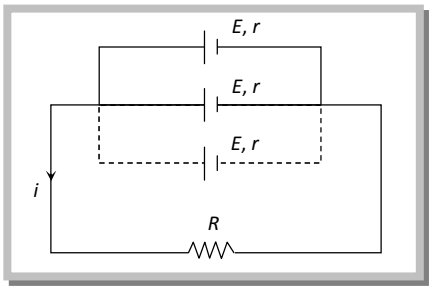
Cells are connected in right order	Cells are wrongly connected
	(E1 > E2)





(a) Equivalent emf $E_{eq} = E_1 + E_2$ (b) Current $i = \frac{E_{eq}}{R + r_{eq}}$ (c) Potential difference across each cell $V_1 = E_1 - ir_1$ and $V_2 = E_2 - ir_2$	(a) Equivalent emf Eeq = E1 – E2 (b) Current $i = \frac{E_1 - E_2}{R + r_{eq}}$ (c) in the above circuit cell 1 is discharging so it's equation is $E_1 = V_1 + ir_1 \Rightarrow \boldsymbol{V_1 = E_1 - ir_1}$ and cell 2 is charging so it's equation $E_2 = V_2 - ir_2 \Rightarrow \boldsymbol{V_2 = E_2 + ir_2}$

(2) Parallel grouping: In parallel grouping all anodes are connected at one point and all cathode are connected together at other point.



(i) If n identical cells are connected in parallel

(a) Equivalent emf Eeq = E

(b) Equivalent internal resistance $R_{eq} = r/n$

(c) Main current $i = \frac{E}{R + r/n}$

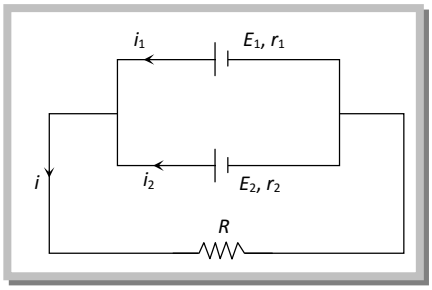
(d) P.d. across external resistance = p.d. across each cell = V = iR

(e) Current from each cell $i' = \frac{i}{n}$ (f) Power dissipated in the circuit $P = \left(\frac{E}{R + r/n}\right)^2 . R$

(g) Condition for max power $R = r/n$ and $P_{\max} = n\left(\frac{E^2}{4r}\right)$ (h) this type of combination is used when nr >> R

(ii) If non-identical cells are connected in parallel: If cells are connected with right polarity as shown below then

(a) Equivalent emf $E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$

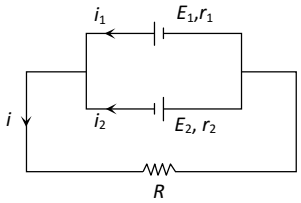


(b) Main current $i = \dfrac{E_{eq}}{r + R_{eq}}$

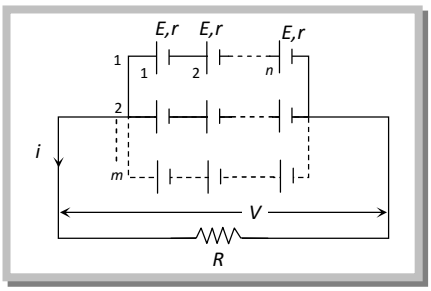
(c) Current from each cell $i_1 = \dfrac{E_1 - iR}{r_1}$ and $i_2 = \dfrac{E_2 - iR}{r_2}$

Note: In this combination if cells are connected with reversed polarity as shown in figure then:

Equivalent emf $\boldsymbol{E_{eq} = \dfrac{E_1 r_2 - E_2 r_1}{r_1 + r_2}}$



(3) Mixed Grouping: If n identical cells are connected in a row and such m rows are connected in parallel as shown.



(i) Equivalent emf of the combination $E_{eq} = nE$

(ii) Equivalent internal resistance of the combination $r_{eq} = \dfrac{nr}{m}$

(iii) Main current flowing through the load $i = \dfrac{nE}{R + \dfrac{nr}{m}} = \dfrac{mnE}{mR + nr}$

(iv) Potential difference across load $V = iR$

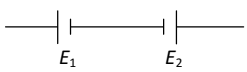
(v) Potential difference across each cell $V' = \dfrac{V}{n}$

(vi) Current from each cell $i' = \dfrac{i}{n}$

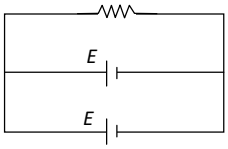
(vii) Condition for maximum power $R = \dfrac{nr}{m}$ and $P_{\max} = (mn)\dfrac{E^2}{4r}$

(viii) Total number of cell = mn

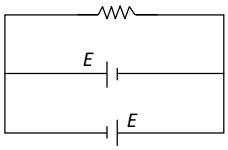
Concepts



In series grouping of cell's their emf's are additive or subtractive while their internal resistances are always additive. If dissimilar plates of cells are connected together their emf's are added to each other while if their similar plates are connected together their emf's are subtractive.



$E_{eq} = E_1 + E_2$ & $r_{eq} = r_1 + r_2$



$E_{eq} = E_1 - E_2 (E_1 > E_2)$ & $r_{eq} = r_1 + r_2$

In series grouping of identical cells. If one cell is wrongly connected then it will cancel out the effect of two cells e.g. If in the combination of n identical cells (each having emf E and internal resistance r) if x cell are wrongly connected then equivalent emf $E_{eq} = (n - 2x)E$ and equivalent internal resistance $r_{eq} = nr$.

In parallel grouping of two identical cell having no internal resistance

$E_{eq} = E$ $\qquad\qquad$ $E_{eq} = 0$

When two cells of different emf and no internal resistance are connected in parallel then equivalent emf is indeterminate, note that connecting a wire with a cell but with no resistance is equivalent to short circuiting. Therefore the total current that will be flowing will be infinity.