Terminal Voltage, EMF, and Circuit Analysis

6 – ELETRIC CIRCUITS

EMF - $\mathscr{E}$

- A device
  - battery
  - electric generator
- that transforms one type of energy
  - chemical
  - mechanical
  - light
- into electrical energy is called a seat or source of electromotive force.
  - emf
  - $\mathscr{E}$.

EMF

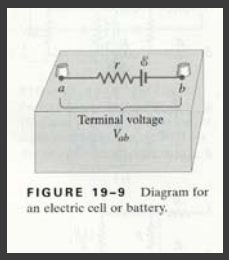
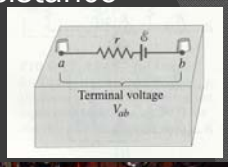


FIGURE 19–9 Diagram for an electric cell or battery.

- The potential difference between the terminals of such a source, when no current flows to an external circuit is called the emf of the source.
- It is not a force measured in Newtons–it's measured in VOLTS since it's a measure of potential difference.

EMF – Internal Resistance



- Every battery has **internal resistance** symbolized by r.
- If you turn on the headlights before you start the car, the lights dim. This is due to the internal resistance of the battery. (insufficient current flow)

Terminal Voltage

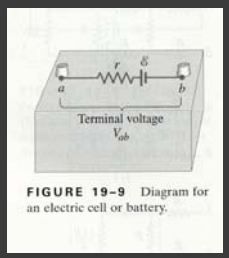


FIGURE 19–9 Diagram for an electric cell or battery.

- **Terminal voltage –**when there is no current drawn from the battery, $V_{ab} = \mathscr{E}$.
- Once you start to draw a current, I, the internal resistance of the battery kicks in.
- The actual voltage delivered is what we call the terminal voltage and is calculated:
- $V_{ab} = \mathscr{E} - Ir$

Kirchhoff's Rules

- Invented Mid-1800's to deal with complicated circuits.
- Based on the laws of conservation of charge and energy.

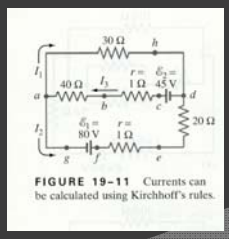


FIGURE 19–11 Currents can be calculated using Kirchhoff's rules.

Kirchhoff's First Rule

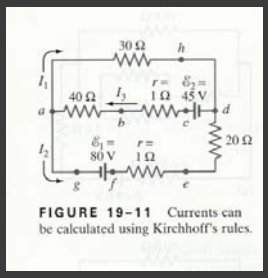
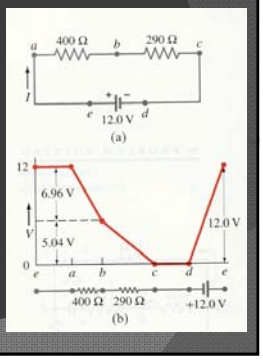


FIGURE 19–11 Currents can be calculated using Kirchhoff's rules.

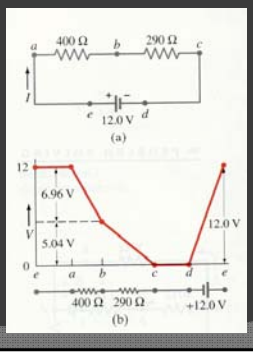
- Junction Rule - At any junction point, the sum of all currents entering the junction must equal the sum of all currents leaving the junction.
- What goes in must come out!
- Conservation of Charge
- $I_1 + I_2 = I_3$

Kirchhoff's Second Rule

- Loop Rule - The sum of the changes in potential around any closed path of a circuit must be zero.
- Conservation of Energy



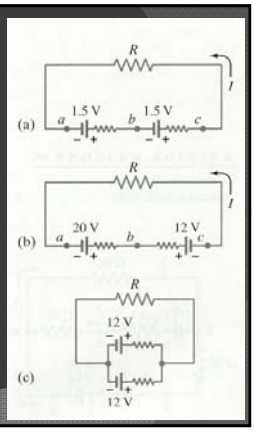
Kirchhoff's Second Rule



- V = IR
- I = V/R = 12.0V/690Ω
  - = .0174 A
- point e to point a no Δ
- a to b
  - V=IR=400Ω*.0174A=-6.96V
- b to c
  - V=IR=290Ω*.0174A=-5.04V
- c to d no Δ
- d to e V= +12.0V
- 12.0V - 6.96V -5.04V =0

EMF in Series

- Sr.V = In Series, resistances and Voltages add.
- a) 1.5V + 1.5V = 3.0V
- b) One is backward!
  - Pick a direction
  - Follow the loop
    - Start at a, counter-clockwise
  - - to +, add (a to b, +20V)
  - + to -, subtract (b to c, -12V)
  - +20-12 = 8V
  - If you wind up with a negative EMF, then the current is in the *opposite* direction.



EMF in Series

- b) Why Why Why?
- It seems silly to have an EMF in backwards,
- BUT this is how battery chargers and the alternators in cars work.
- It forces electrons to the negative terminal removing them from the positive.