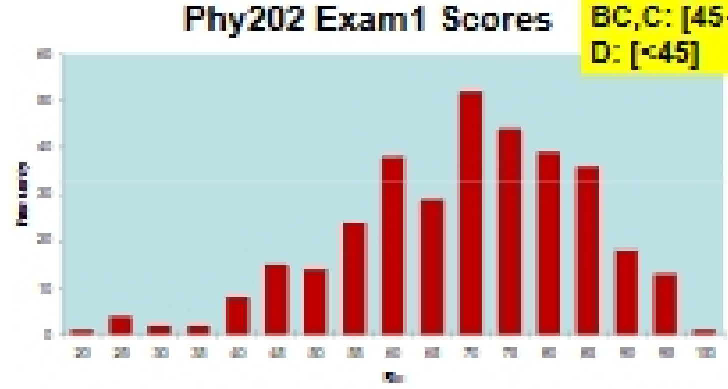
Physics 202, Lecture 10

Today's Topics

- Direct Current Circuits (Ch. 28)
  - Basic circuit components(ℰ, R, ...)
  - Kirchhoff's Rules
  - Circuits Analysis (For circuits of R's and ℰ's)
- Preview Requirements:
  emf, junction rule, loop rule, ...
- Next Tuesday:
  RC circuit (ch. 28.4), Magnetic Field(ch. 29.1-3)

Exam 1 Result

Median: 69
A: [83-97]
AB,B: [69-82]
BC,C: [45-68]
D: [<45]



Note: Letter boundaries are for reference only. (Based on nominal A=15%, B=50% etc. and subject to final curve at the end of semester)

Basic Circuit Components

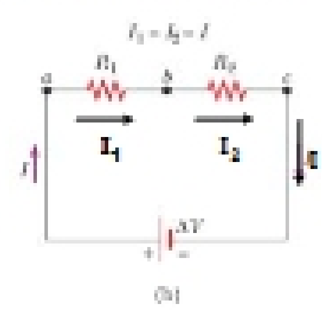
Component	Symbol	Behavior in circuit
Ideal battery, emf		$\Delta V = V_+ - V_- = \mathcal{E}$
Resistor		$\Delta V = -IR$
Realistic Battery		→
(Ideal) wire		$\Delta V=0$ (→ R=0, L=0, C=0)
Capacitor		$\Delta V = V_- - V_+ = -q/C$, $dq/dt = I$
Inductor		$\Delta V = -L dI/dt$
(Ideal) Switch		L=0, C=0, R=0 (on), R=∞ (off)
Transformer	Future Topics	
Diodes, Transistors,...		

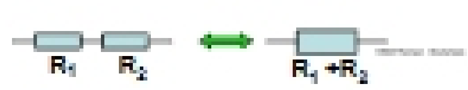
Simple Circuit 1: Resistors In Series

- Exercise: show $R_{eq}=R_1+R_2$.
  - $I_1=I_2=I$
  - $\Delta V = V_{R1}+V_{R2}$
    $= IR_1+IR_2$

  → $\Delta V = I(R_1+R_2)$

  i.e. $R_{eq}=R_1+R_2$

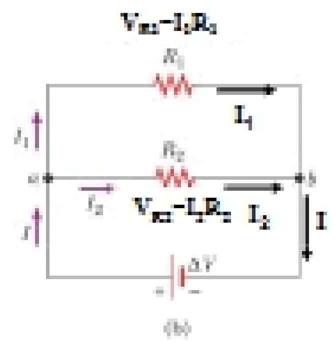




- In general: $R_{eq}=R_1+R_2+R_3+ ....$

Simple Circuit 2: Resistors In Parallel

- Show $1/R_{eq}=1/R_1+1/R_2$.
  - $V_{R1}=V_{R2}=\Delta V$
  - $I_1+I_2=I$
  - $\rightarrow I_1R_1/R_1+I_2R_2/R_2=I$
  - $\rightarrow \Delta V\,(1/R_1+1/R_2)=I$
  - $\rightarrow \Delta V=I\;1/(1/R_1+1/R_2)$ → R_{eq}



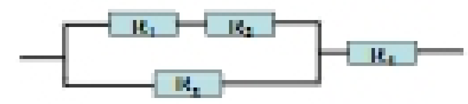
i.e.

- In general: $1/R_{eq}=1/R_1+1/R_2+1/R_3+\ldots$

Quiz/Exercise: Equivalent Resistance of a Combined Parallel and Serial Circuit

- What is the R_{eq} for the combination shown?
  $R_1=R_2=1\Omega$, $R_3=2\Omega$, $R_4=4\Omega$.

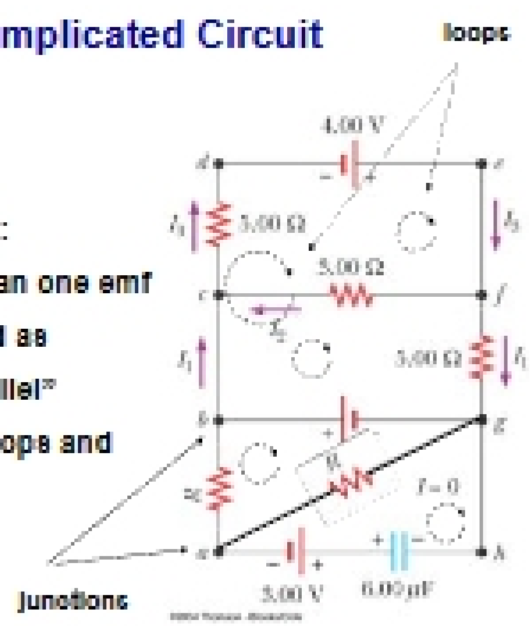
1. 8Ω
2. 6Ω
3. ➔ 5Ω
4. None of above



A Complicated Circuit

A complicated circuit :

- May contain more than one emf
- May not be simplified as "in series" or "in parallel"
- May contain multi loops and junctions.

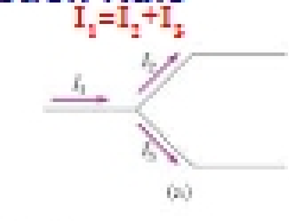


Kirchhoff's Rules: Junction Rule

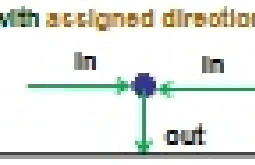
- Junction Rule (Charge conservation):

The sum of currents entering any junction equals the sum of currents leaving that junction.

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



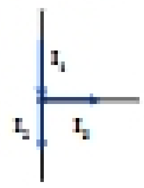
- In practice, the classifications of "in" and "out" are determined by assigned direction for each current.
  The assignment of current directions can be arbitrary. They may not be the same as actual directions, which are not known a prior.
  - "in" : current with assigned direction towards junction
  - "out" : current with assigned direction off junction



(Very) Quick Quiz: Junction Rule

- What is the junction rule for the current assignment shown?

1. $I_1+I_2=I_3$
2. $I_1=I_2+I_3$ ←
3. $I_1-I_2=I_3$

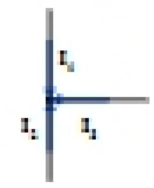


Although equation 2 and 3 are equivalent, equation 3 does not follow template form $I_{in}=I_{out}$

Quick Quiz: Junction Rule

- What is the junction rule for the current assignment shown?

1. $I_1+I_2=I_3$
2. $I_1+I_2+I_3=0$ ←
3. Neither

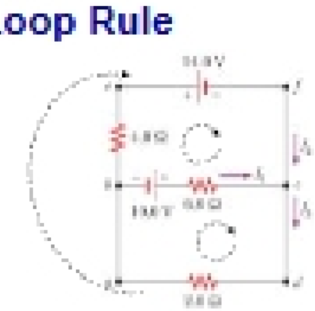


While the actual currents can not all goes into a junction, the assigned currents can.

Kirchhoff's Rules: Loop Rule

- Loop Rule (Energy Conservation): The sum of potential drops across components along any closed circuit loop must be zero.

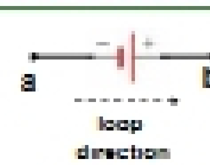
$$\Sigma \Delta V = 0$$



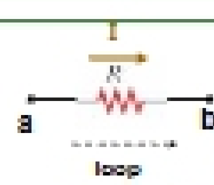
- The potential "drop" across a component is always defined as $V_{down\ stream\ end} - V_{up\ stream\ end}$ where, the stream direction is the same as loop direction
- The exact expression of the potential drop is determined by the type of component and the assigned current direction. (See next slides)

Determine Potential Difference

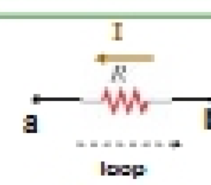
$\Delta V=V_b-V_a= -\varepsilon$



$\Delta V=V_b-V_a= +\varepsilon$



$\Delta V=V_b-V_a= -IR$



$\Delta V=V_b-V_a= +IR$