Homework Changes

• HW solution #1 posted
Ohm’s Law

• Ohm’s Law: \( V = IR \)

• Power \( P(t) = I(t)V(t) \), thus:
  
  \[
  P(t) = [I(t)]^2R \\
  P(t) = [V(t)]^2/R
  \]

• Dissipated power given off as heat
Resistance

- Physical property of material: resistivity \( \rho \) (\( \Omega \cdot m \))
- Resistance for cylinder: \( R=\rho L/A \) (\( \Omega \))
Conductance

- Physical property of material: conductivity $\sigma$ (S/m)
- Conductance for cylinder $G = \sigma A / L$ (S or $\Omega$)
Example 1

• Find the resistance of a carbon rod with $L=1 \text{ cm}$ and $A=0.1 \text{ cm}^2$

• Find the current flow and power dissipated through the carbon rod when connected to a 1.5 V battery:
Example 1: Solution

- Find the resistance of a carbon rod with \( L = 1 \text{ cm} \) and \( r = 0.02 \text{ cm} \):
  \[
  \rho = 2400 \times (17 \text{ n}\Omega \cdot \text{m}) = 40.8 \text{ } \mu\Omega \cdot \text{m}
  \]
  \[
  R = \frac{\rho L}{A} = \frac{(40.8 \text{ } \mu\Omega \cdot \text{m})(1 \text{ cm})}{\pi (0.02 \text{ cm})^2} = 3.25 \Omega
  \]

- Find the current flow through the carbon rod when connected to a 1.5 V battery:
  \[
  I = \frac{V}{R} = \frac{1.5 \text{ V}}{3.25 \Omega} = 0.46 \text{ A}
  \]

- Find the power dissipated:
  \[
  P = IV = (0.46 \text{ A})(1.5 \text{ V}) = 0.69 \text{ W}
  \]
Example 2: Series Circuits

• Calculate the effective resistance of 3 resistors in series with resistances 2 Ω, 3 Ω, and 5 Ω:

\[\begin{array}{c}
2 \, \Omega \\
\| \| \\
3 \, \Omega \\
\| \\
5 \, \Omega
\end{array}\]

• Calculate the current generated when powered by a 9 V battery:

\[\begin{array}{c}
2 \, \Omega \\
\| \\
3 \, \Omega \\
\| \\
5 \, \Omega \\
\| \\
9 \, V
\end{array}\]
Example 2: Solution

- Calculate the effective resistance of 3 resistors in series with resistances 2 Ω, 3 Ω, and 5 Ω:

\[
R_{\text{eff}} = \sum_{i=1}^{3} R_i = 2 \, \Omega + 3 \, \Omega + 5 \, \Omega = 10 \, \Omega
\]
Example 2: Solution Cont’d

• Calculate the current generated when powered by a 9 V battery:

\[ I = \frac{V}{R_{\text{eff}}} = \frac{9 \text{ V}}{10 \Omega} = 0.9 \text{ A} \]
Example 3: Parallel Circuits

• Calculate effective resistance of 3 resistors of resistances 4, 6, and 12 Ω:

\[ \begin{array}{ccc}
4 \Omega & 6 \Omega & 12 \Omega \\
\end{array} \]

• Calculate current when connected to two 1.5 V batteries in series:
Example 3: Solution

- Calculate effective resistance of 3 resistors of resistances 4, 6, and 12 Ω:

\[
R_{\text{eff}}^{-1} = \sum_{i=1}^{3} R_i^{-1}
\]

\[
R_{\text{eff}}^{-1} = \frac{1}{4} + \frac{1}{6} + \frac{1}{12} = 0.5 \text{ S}
\]

\[
R_{\text{eff}} = 2 \Omega
\]
Example 3: Parallel Circuits

- Calculate current when connected to two 1.5 V batteries in series:

\[ I = \frac{V_{\text{eff}}}{R_{\text{eff}}} = \frac{1.5 + 1.5 \text{ V}}{2 \ \Omega} = 1.5 \text{ A} \]
Current-Voltage Relations

• Resistor

\[ V = IR \]

• Ideal voltage source

\[ V = V_s \]

• Ideal current source

\[ I = I_s \]
Controlled Ideal Sources

- Can use current or voltage to control output current or voltage

### Control type

<table>
<thead>
<tr>
<th>Output type</th>
<th>Voltage</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Voltage</strong></td>
<td>VCVS V=(\mu V_x)</td>
<td>CCVS V=IR</td>
</tr>
<tr>
<td><strong>Current</strong></td>
<td>VCCS I=gV</td>
<td>CCCS I=(\beta I_x)</td>
</tr>
</tbody>
</table>
Homework #3 for Monday

• DeCarlo & Lin, 3rd Edition, Chapter 1
  – Problem 23
  – Problem 28
  – Problem 38

• All homework posted on Blackboard