UBC Physics 102

Lecture 9

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Outline

Electric power [Text: Sect. 25-5]

- **Definition:** *Power*
  - Rate energy is delivered to component,

$$P = \frac{dU}{dt}.$$

  - Energy usually turned into heat.
  - Energy delivered by charges moving through potential difference.
  - Across potential V energy of little charge dq changes by $dU = dq\,V$ so power consumed is

$$P = \frac{dq}{dt}V = IV.$$

Electric power, contd

- **Unit: Watt,** W
  - Unit of power,

$$1\ \mathrm{W} = 1\ \mathrm{J/s}.$$

- **Discussion: Power in resistor**
  - Across resistance R voltage drop is $\boxed{V = IR}$.
  - So power delivered is

$$P = IV = I^2R = \frac{V^2}{R}.$$

  - Only true for constant R.

Alternating current [Text: Sect. 25-7]

- **Interactive Quiz: PRS 09a**
- **Definition:** *Alternating current, ac*
  - ac generated by oscillating voltage,

$$V = V_0 \sin \omega t.$$

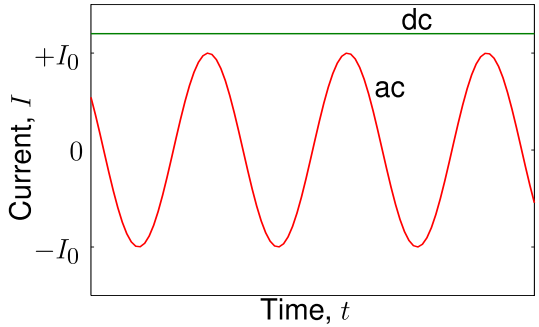
  - V_0 is **peak voltage**, magnitude of V.
  - Current across resistor R is

$$I = \frac{V}{R} = I_0 \sin \omega t.$$

  - $I_0 = \frac{V_0}{R}$ is **peak current**, magnitude of I.

Alternating current, contd

- **Definition:** *Alternating current, ac, contd*
  - So current alternates in direction.



Alternating current, contd

- **Derivation: RMS voltage and current, V_{RMS} and I_{RMS}**
  - Consider sinusoidal quantity

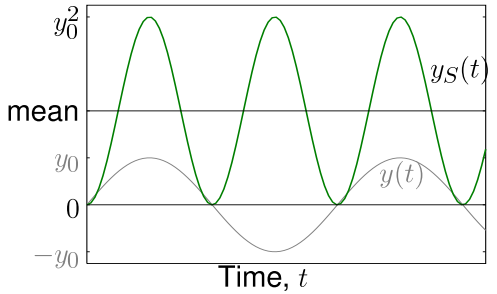
$$y = y_0 \sin \omega t$$

  - Average is zero but can compute an "effective" average, called RMS.
  - RMS = Root (of the) Mean (of the) Square.
  - 3 Steps. Step 1: Square.

$$y_S = y^2 = y_0^2 \sin^2 \omega t.$$

Alternating current, contd

- **Derivation: RMS voltage and current, V_{RMS} and I_{RMS}, contd**
  - Step 2: Mean (average).



$$y_{MS} = \text{mean}(y_S) = \frac{1}{2} y_0^2.$$

Alternating current, contd

- **Derivation: RMS voltage and current, V_{RMS} and I_{RMS}, contd**
  - Step 3: Root.

$$y_{RMS} = \sqrt{y_{MS}} = \frac{1}{\sqrt{2}} y_0.$$

  - Applies to sinusoidal voltage and current,

$$V_{RMS} = \frac{1}{\sqrt{2}} V_0, \; I_{RMS} = \frac{1}{\sqrt{2}} I_0.$$

  - RMS values more useful than peak values.
  - Most ac voltages and currents reported are RMS.

Alternating current, contd

- **Derivation: RMS voltage and current, V_{RMS} and I_{RMS}, contd**
  - Example: RMS wall voltage is 120 V, peak is $V_0 = \sqrt{2}\, V_{RMS} = 170$ V.
- **Interactive Quiz: PRS 09b**
- **Discussion: Average power, $\overline{P}$**
  - If V and I not constant then nor is power.
  - If sinusoidal then power at any moment is

$$P = IV = I_0 V_0 \sin^2 \omega t.$$

Alternating current, contd

- **Discussion: Average power, $\overline{P}$, contd**
  - More useful to know average power, $\overline{P}$. Average of $\sin^2 \omega t$ is $\frac{1}{2}$ so

$$\overline{P} = \frac{1}{2} I_0 V_0.$$

  - Or, written in terms of I_{RMS} and V_{RMS},

$$\overline{P} = I_{RMS} V_{RMS}.$$

  - This is ac equivalent of power for dc circuit, $\boxed{P = IV}$.

End

- **Practice Problems:**
  - Ch. 25: Q. 1, 3, 5, 7, 11, 17.
  - Ch. 25: Pr. 1, 3, 5, 7, 9, 11, 13, 15, 25, 27, 29, 31, 33, 35, 37, 39, 43, 45, 47, 49, 55, 57, 59, 65, 67, 69, 71, 75.
- **Interactive Quiz: Feedback**