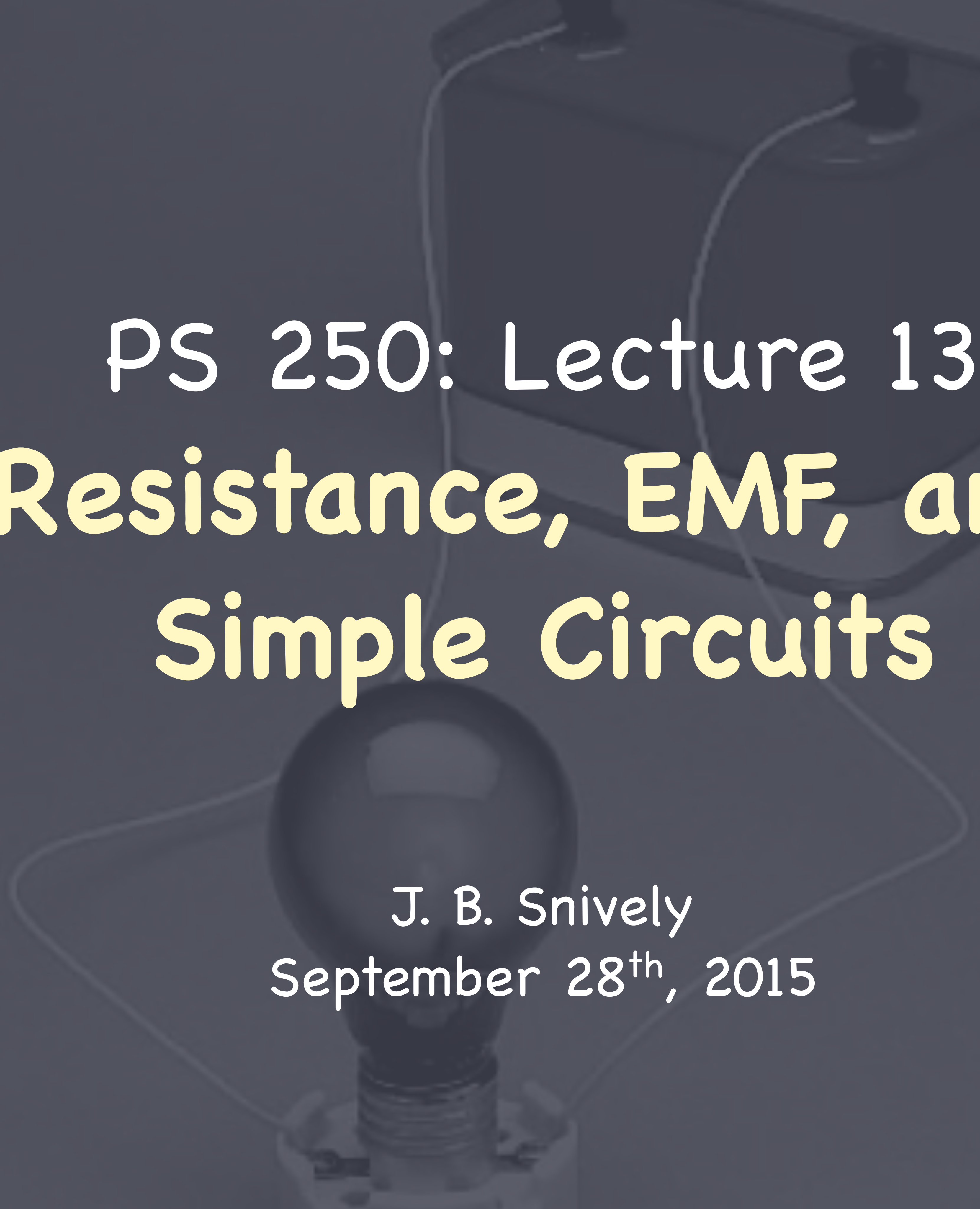

PS 250: Lecture 13

Resistance, EMF, and Simple Circuits

J. B. Snively

September 28^{th}, 2015

Today's Class

- **Review:** Resistivity and Resistance
- **Electromotive Force (EMF)**
- **Energy and Power**
- **Summary**

Resistivity

$$\boxed{\rho = \frac{E}{J}}$$

Units [Ohms*Meter], where
$[V/m]/[A/m^2]=[V*m/A]=[\Omega*m]$

Conversely, conductivity has units $[\Omega*m]^{-1}$!

In vector form: $$\boxed{\vec{E} = \rho\vec{J}}$$ Applies for "Ohmic conductors"

Resistance

Ohm's Law

$$\boxed{\vec{E} = \rho \vec{J}} \Rightarrow \boxed{V = IR}$$

Resistivity can be related to Resistance:

$$\boxed{R = \frac{\rho L}{A}}$$

Resistivity depends on material properties and temperature, Resistance is also a function of length and cross-sectional area of the conductor!

Today's Class

- **Review:** Resistivity and Resistance
- **Electromotive Force (EMF)**
- **Energy and Power**
- **Summary**

Circuits

- Current only flows in **"complete circuits"** – Otherwise, conductors simply reach an equilibrium (E=0, static case).
- Flow is facilitated by **EMF (Electromotive Force)**, in units Joules per Coulomb [J]/[C], aka Volts [V] (i.e., due to a battery, generator, solar cell)
- An **ideal EMF source** provides constant potential difference for any current drawn – Unfortunately, it also does not exist!

Ideal EMF Source

Maintains Constant Potential Difference:

$$V_{ab} = \mathcal{E}$$

Can supply any Current I into Resistor R:

$$\mathcal{E} = V_{ab} = IR$$

Of course, this is way too good to be true!

Real EMF Source

Has an internal resistance “r”:

$$V_{ab} = \mathcal{E} - Ir$$

… this leads to reduced potential difference at the terminals (V_{ab}).

V_{ab} decreases linearly as current demand increases.

Today's Class

- **Review:** Resistivity and Resistance
- **Electromotive Force (EMF)**
- **Energy and Power**
- **Summary**

Power

(Rate of Energy Transfer)

- Rate of energy transfer [J/s] = [W]
- **Recall:** Volts [J/C], Amperes [C/s]
- "Rate at which energy is delivered or extracted from a circuit element"

$$\boxed{P = V_{ab} I}$$

$$\boxed{\frac{[\mathrm{J}]}{[\mathrm{C}]}\frac{[\mathrm{C}]}{[\mathrm{s}]} = \frac{[\mathrm{J}]}{[\mathrm{s}]} = [\mathrm{W}]}$$

Power

Dissipation of Resistors

First, recall that:

$$P = V_{ab}I \quad \text{and} \quad V_{ab} = IR$$

By substituting in Ohm's Law, we can obtain:

$$\boxed{P = V_{ab}I = I^2R = \frac{V_{ab}^2}{R}}$$

In a resistor, power is dissipated as heat!
Practical resistors have a max power rating.

Summary / Next Class:

- **Work** on Mastering Physics for Wednesday and Homework for Friday
- **Prepare** to discuss **26.1-26.2**.