FI 2A2 ELECTROMAGNETISMO
Clase 13
Corriente Eléctrica-II

LUIS S. VARGAS
Area de Energía
Departamento de Ingeniería Eléctrica
Universidad de Chile

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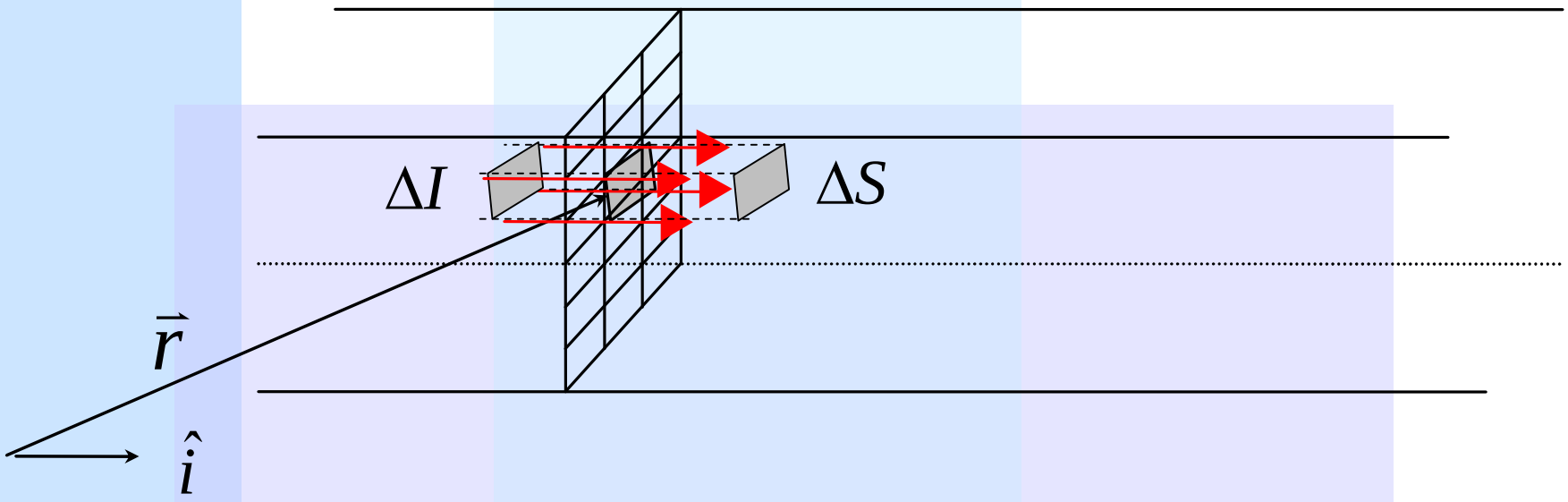
- Ley de Ohm
- Efecto Joule
- Ejemplo

Densidad de Corriente

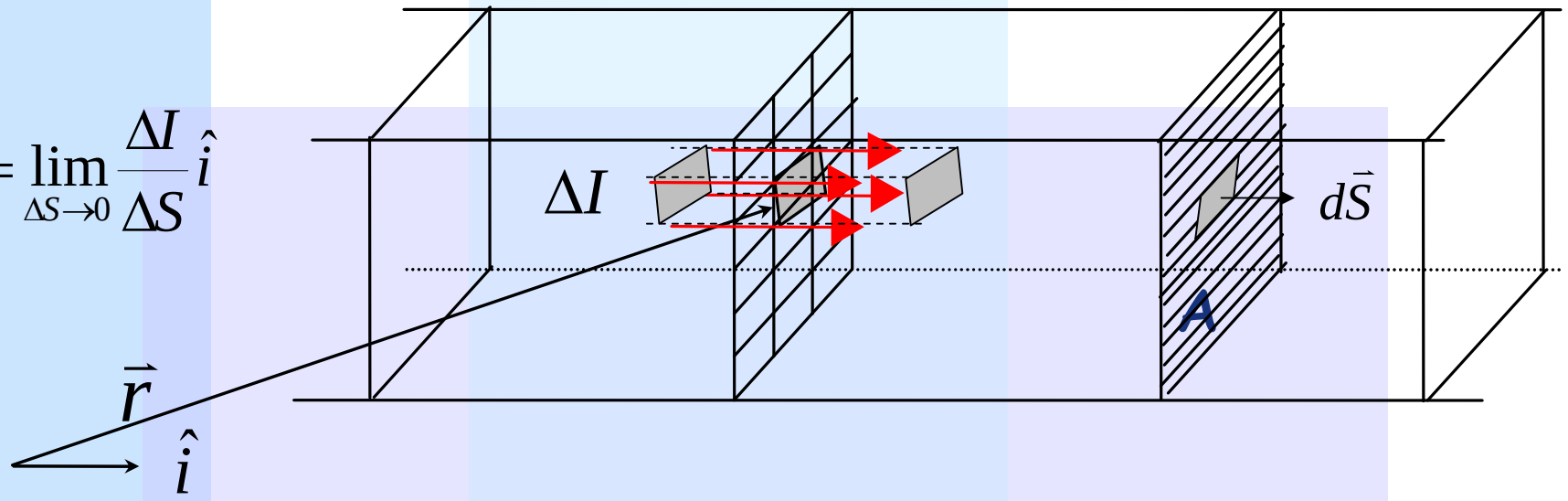


Vector densidad de corriente

$$\vec{J}(\vec{r}) = \lim_{\Delta S \to 0} \frac{\Delta I}{\Delta S} \hat{i}$$

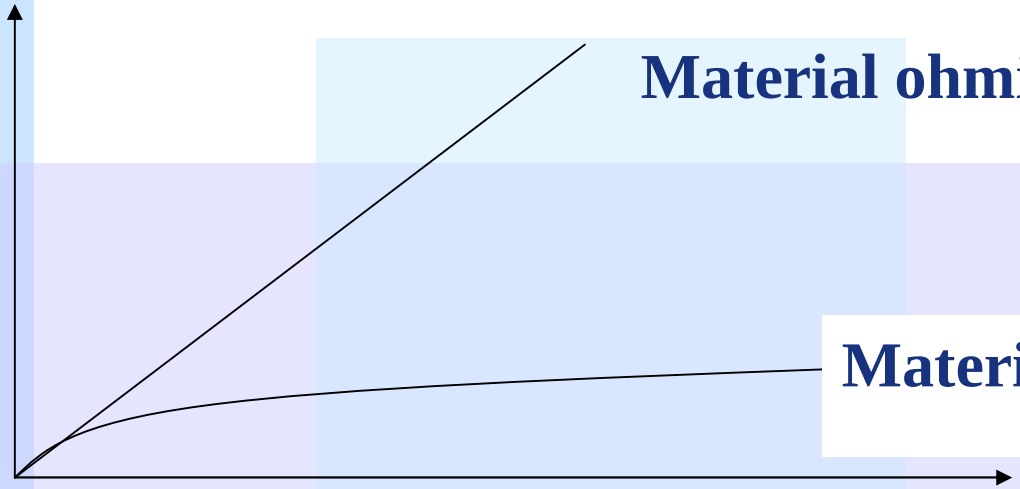
Densidad de Corriente

$$\vec{J}(\vec{r}) = \lim_{\Delta S \to 0} \frac{\Delta I}{\Delta S} \hat{i}$$



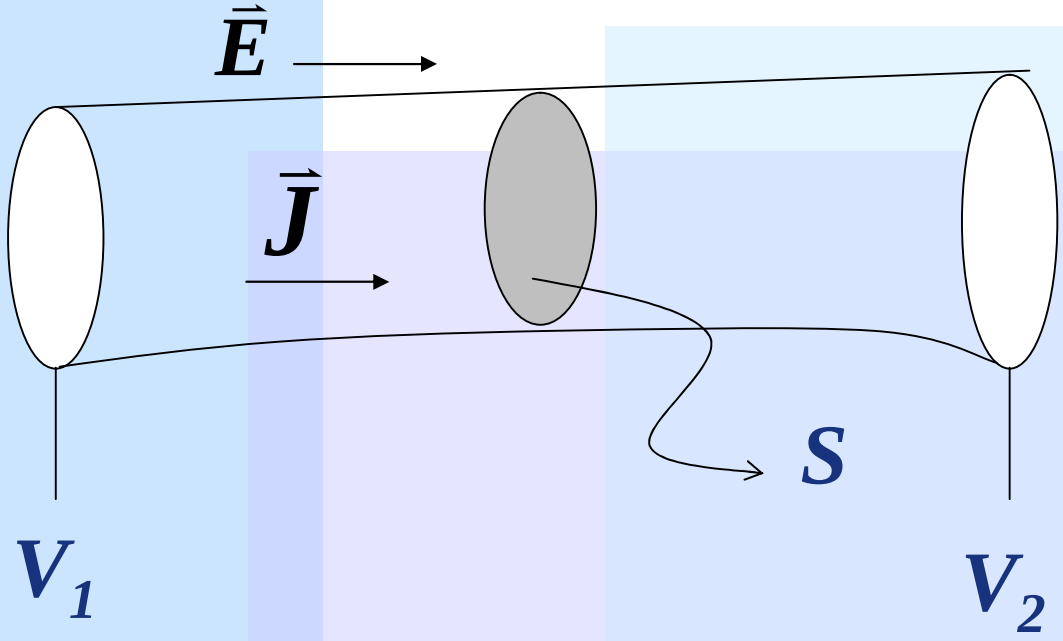
Corriente a través de A $$I = \iint_A \vec{J} \cdot d\vec{S}$$

Ley de Ohm



$$\vec{J} = g\,\vec{E} \quad \Rightarrow \Delta V = RI \qquad R = \rho \times \frac{l}{S}$$

Ley de Ohm



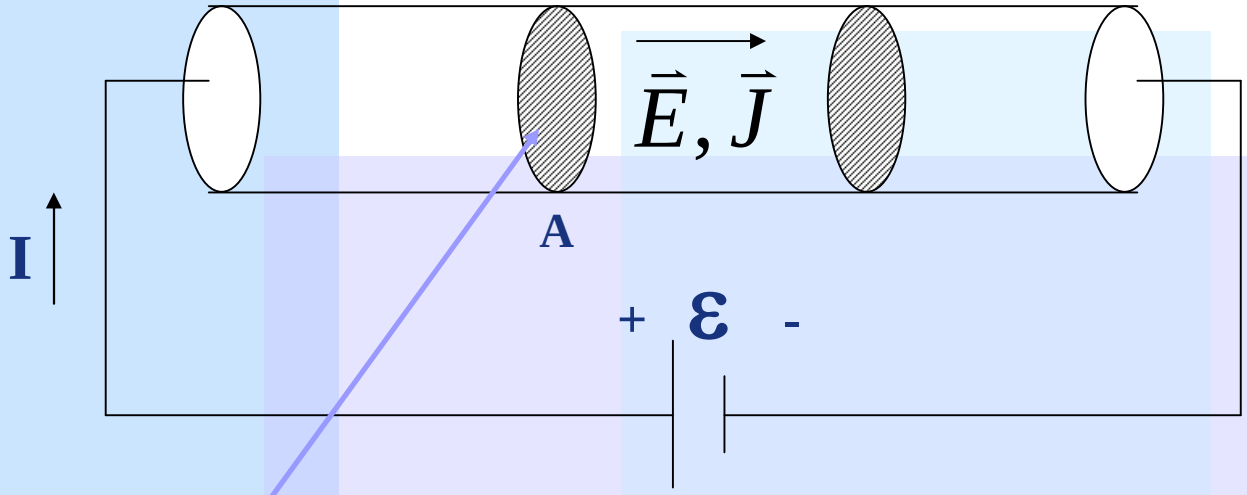
Ley de OHM

$$\vec{J} = g\,\vec{E}$$

$$\Delta V = RI$$

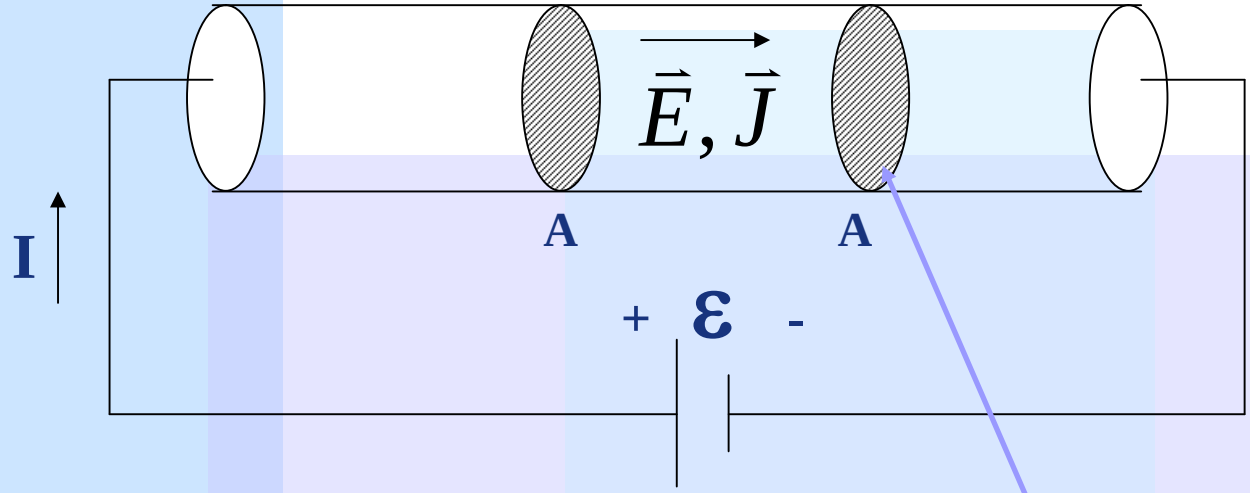
$$R = \frac{\int_1^2 \vec{E}\cdot d\vec{l}}{\iint_S g\,\vec{E}\cdot d\vec{S}}$$

Efecto Joule



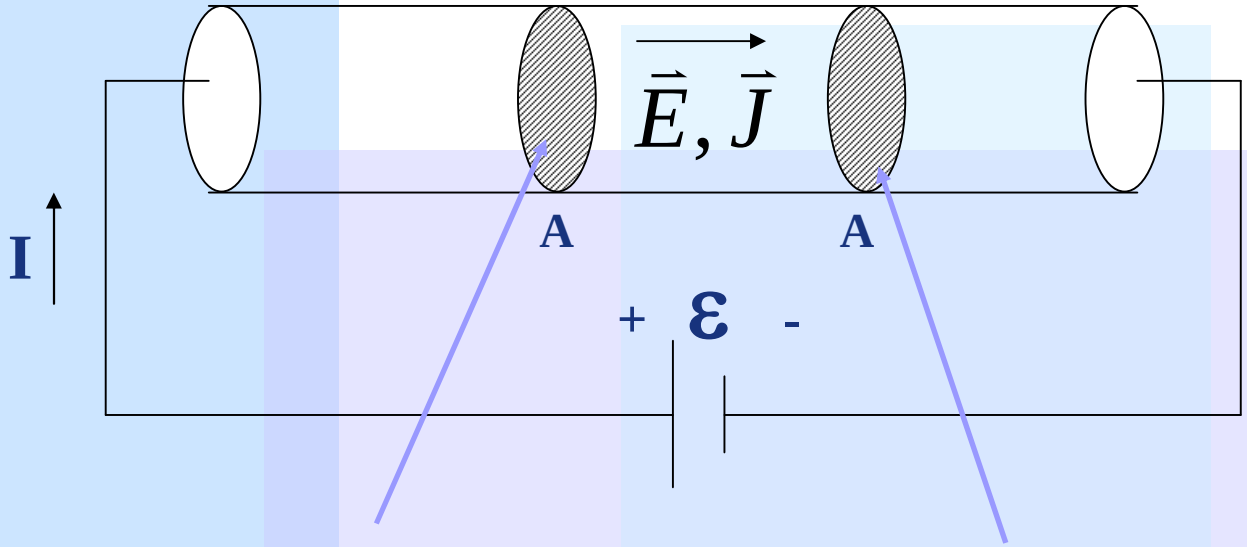
$U_1 = \Delta Q_1 \cdot V_1$ **energía de la carga en el disco 1**

Efecto Joule



$U_2 = \Delta Q_2 V_2$ **energía de la carga en el disco 2**

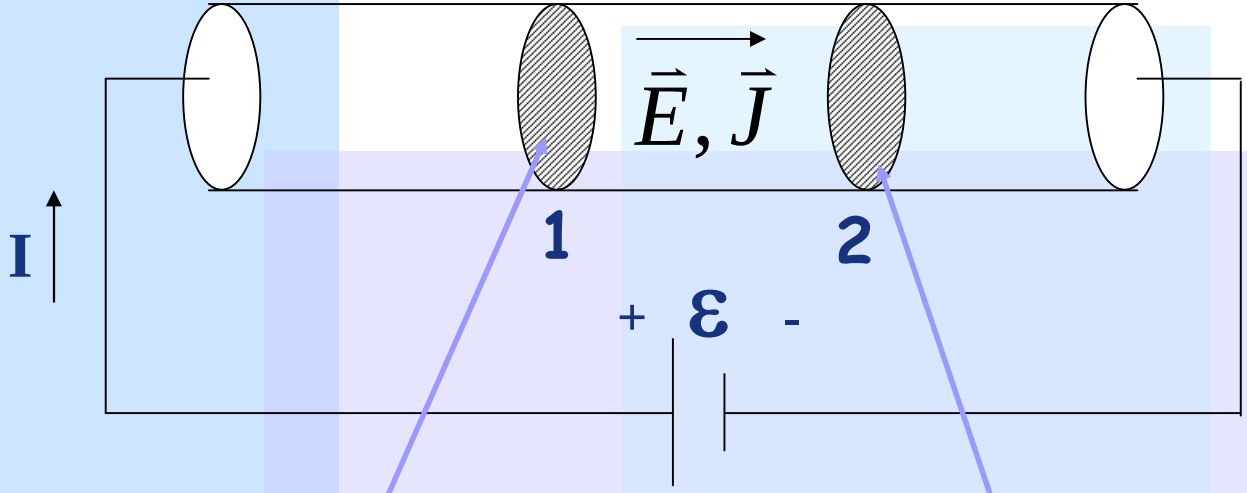
Efecto Joule



Diferencia de energía entre 1 y 2

$$\Delta U = \Delta Q_1 V_1 - \Delta Q_2 V_2$$

Efecto Joule



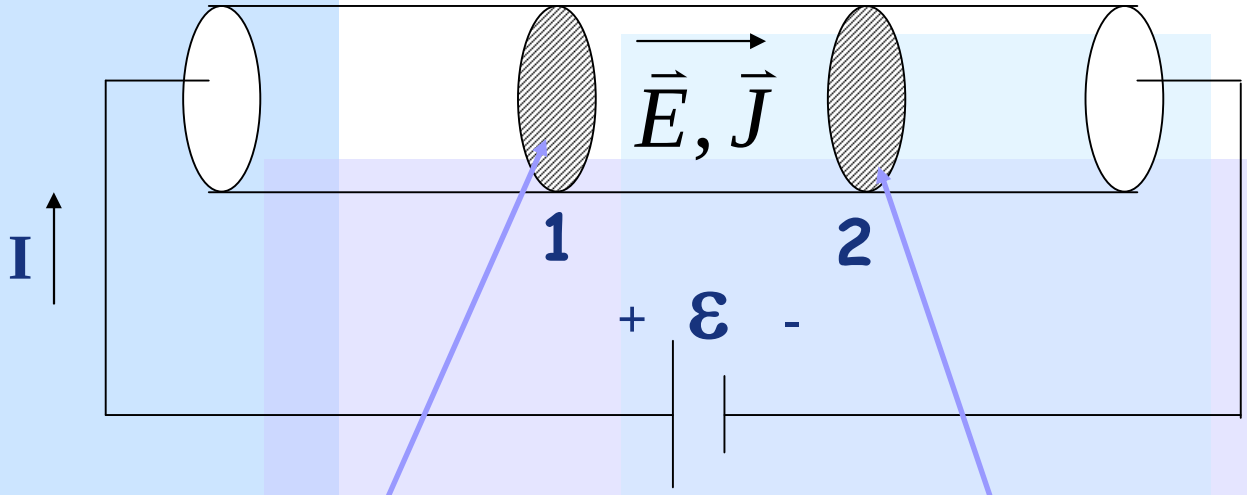
$$\Delta Q_1 = \Delta Q_2$$

$$\Delta U = \Delta Q\left(V_1 - V_2\right)$$

Potencia es la derivada de la Energia

$$P = \frac{\Delta U}{\Delta t} = \frac{\Delta Q}{\Delta t}\left(V_1 - V_2\right)$$

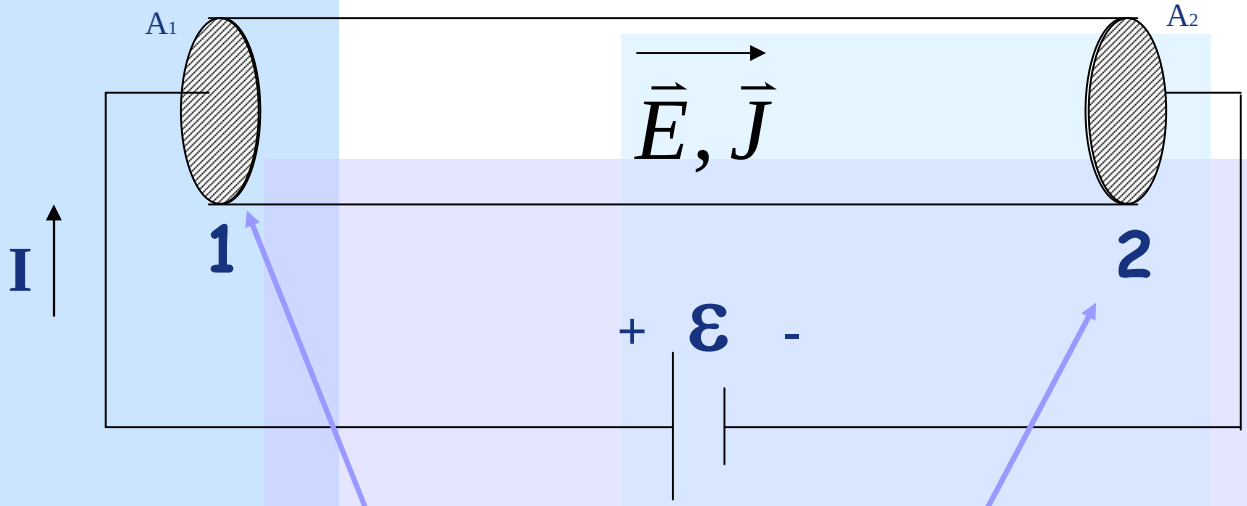
Efecto Joule



$$\frac{\Delta Q}{\Delta t} = I$$

$$P = \frac{\Delta U}{\Delta t} = \frac{\Delta Q}{\Delta t}\left(V_1 - V_2\right)$$

Efecto Joule

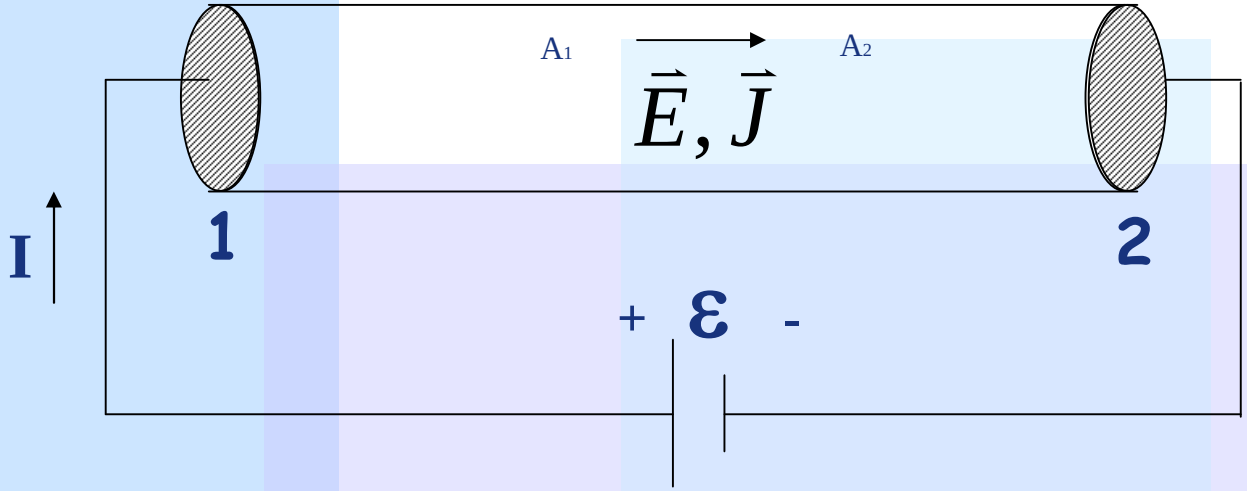


- Calor disipado
- Fem proporciona energía

Potencia es diferencia de potencial por corriente

$$\Rightarrow P = I\Delta V$$

Efecto Joule

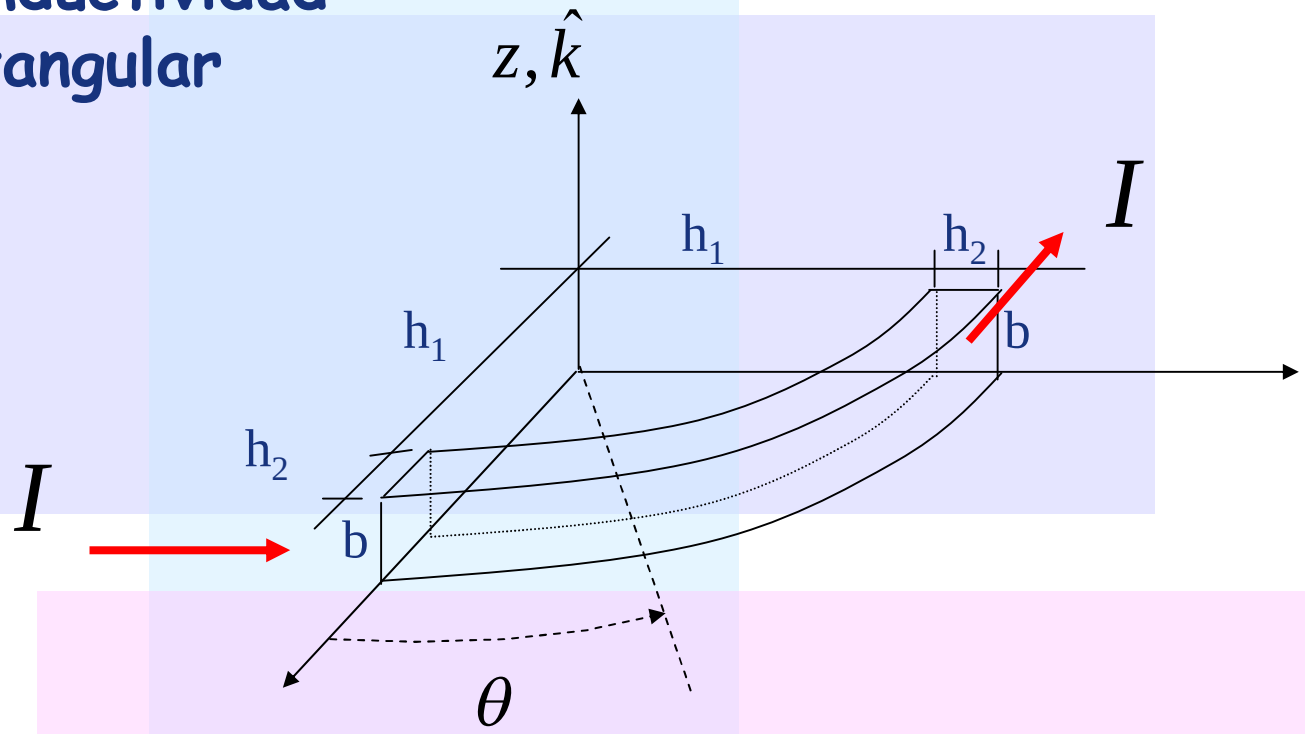


- Calor disipado
- Fem proporciona energía

$$\Delta V = RI \Rightarrow P = I \cdot R \cdot I = RI^2 \quad \text{ó} \quad P = \frac{\Delta V^2}{R}$$

Ejemplo

Una barra de cobre pandeada de conductividad g y sección rectangular



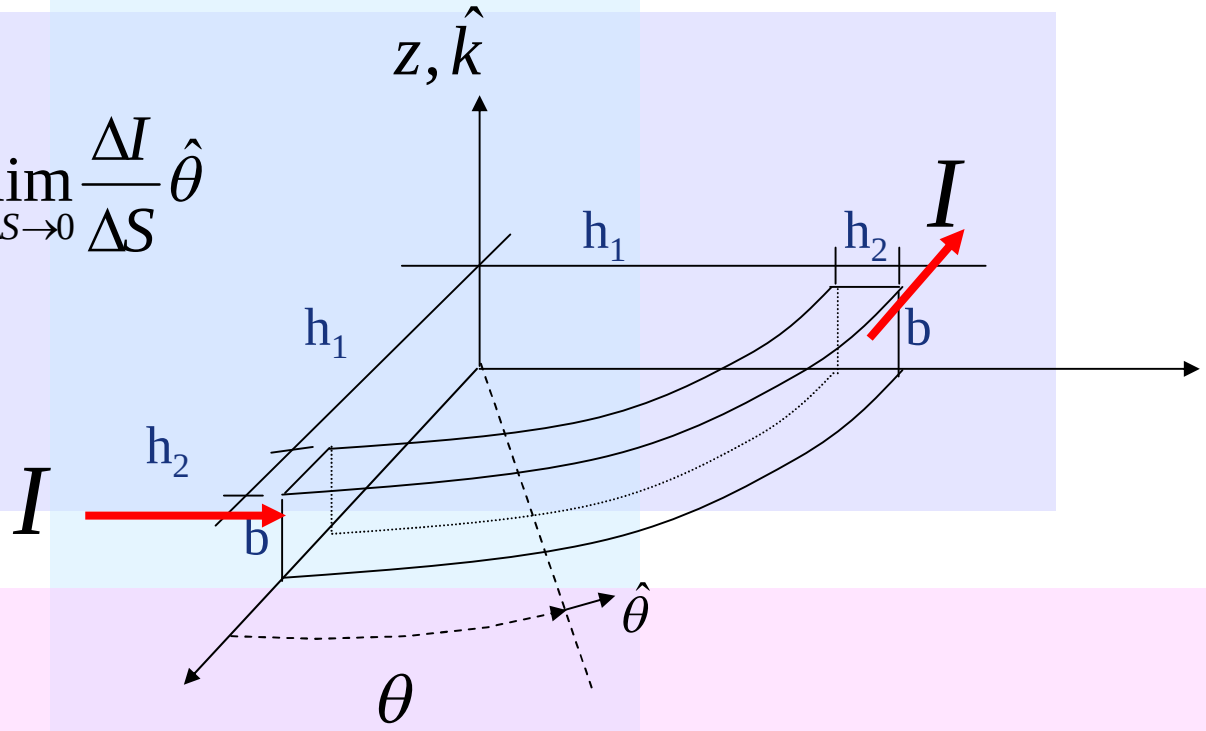
Ejemplo

Vector densidad de corriente

$$I = \iint_A \vec{J} \cdot d\vec{S}$$

$$\vec{J}(\vec{r}) = \lim_{\Delta S \to 0} \frac{\Delta I}{\Delta S} \hat{\theta}$$

$$\vec{J}(\vec{r}) = \frac{I}{b h_2} \hat{\theta}$$



Suponemos que la corriente se distribuye en forma uniforme

Ejemplo

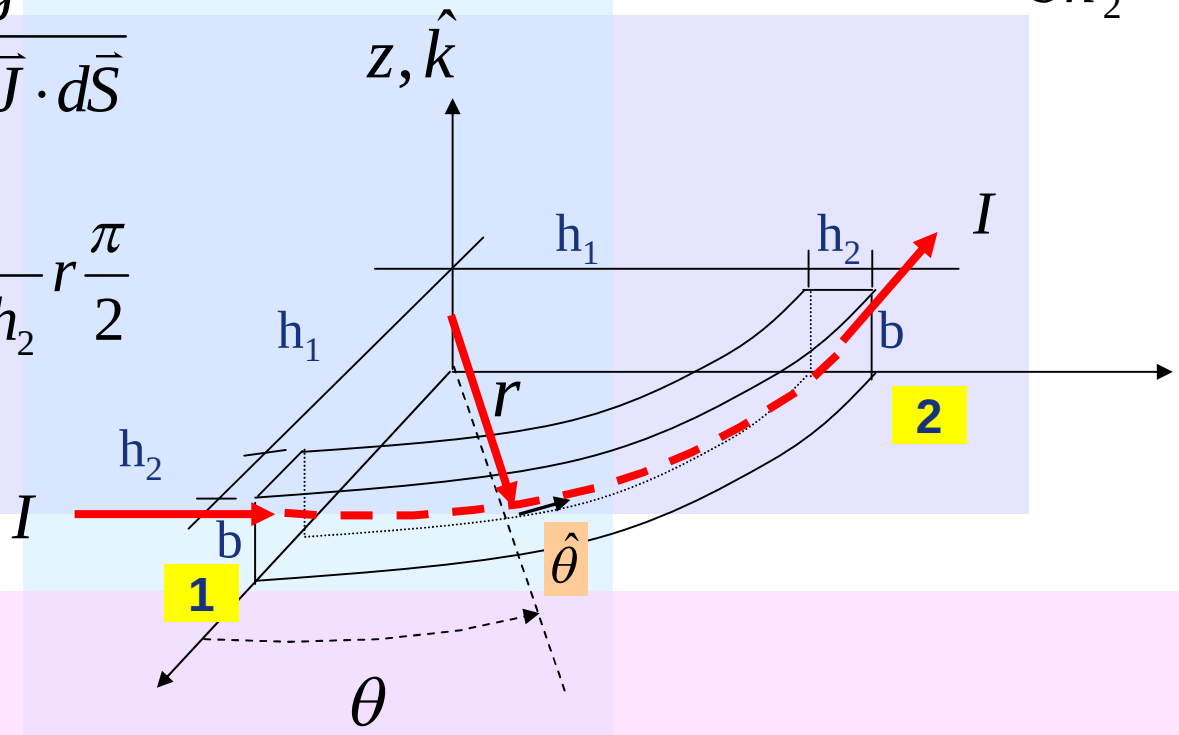
$$\vec{J}(\vec{r}) = \frac{I}{bh_2}\hat{\theta}$$

Resistencia $R = \dfrac{\int_1^2 \frac{\vec{J}}{g}\cdot d\vec{l}}{\iint_S \vec{J}\cdot d\vec{S}}$

$$d\vec{l} = r\,d\theta\,\hat{\theta} \Rightarrow \int_1^2 \frac{\vec{J}}{g}\cdot d\vec{l} = \frac{I}{gbh_2} r\frac{\pi}{2}$$

$$\iint_S \vec{J}\cdot d\vec{S} = I$$

$$R = \frac{\frac{I}{gbh_2} r\frac{\pi}{2}}{I}$$



Tomando el radio medio

$$r = h_1 + \frac{h_2}{2} \Rightarrow$$

$$R = \frac{\pi}{2gbh_2}\left(h_1 + \frac{h_2}{2}\right)$$

Ejemplo

Resistencia

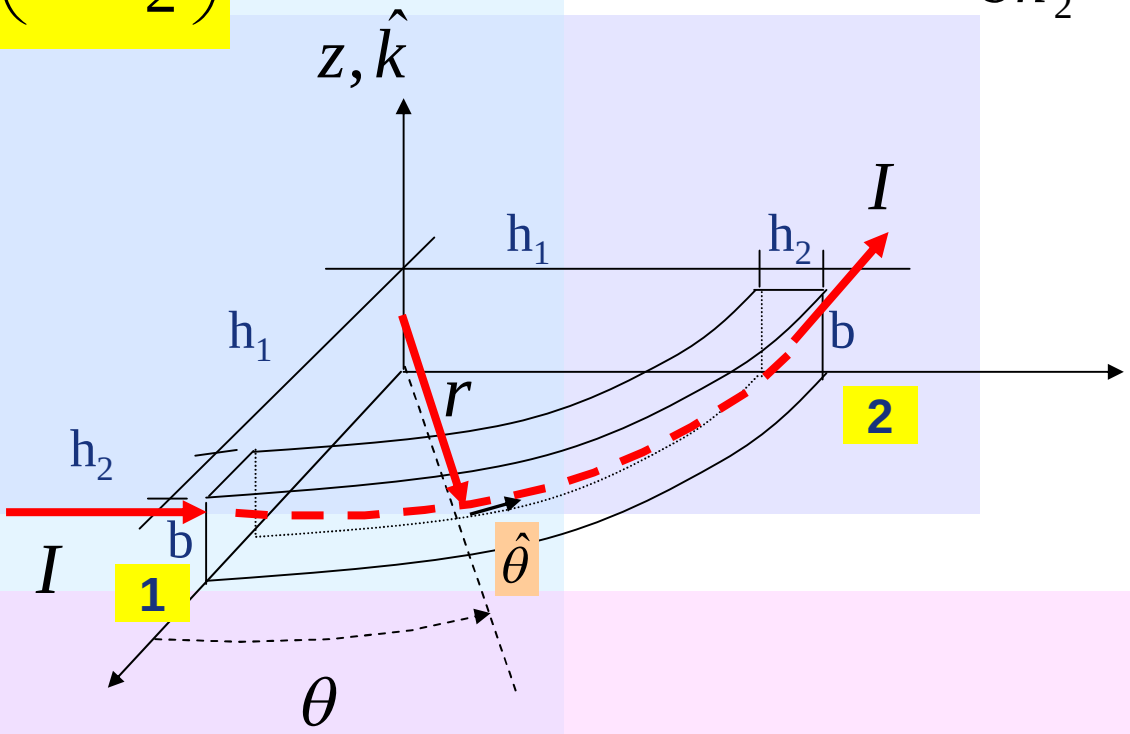
$$R = \frac{\pi}{2gbh_2}\left(h_1 + \frac{h_2}{2}\right)$$

$$\vec{J}(\vec{r}) = \frac{I}{bh_2}\hat{\theta}$$

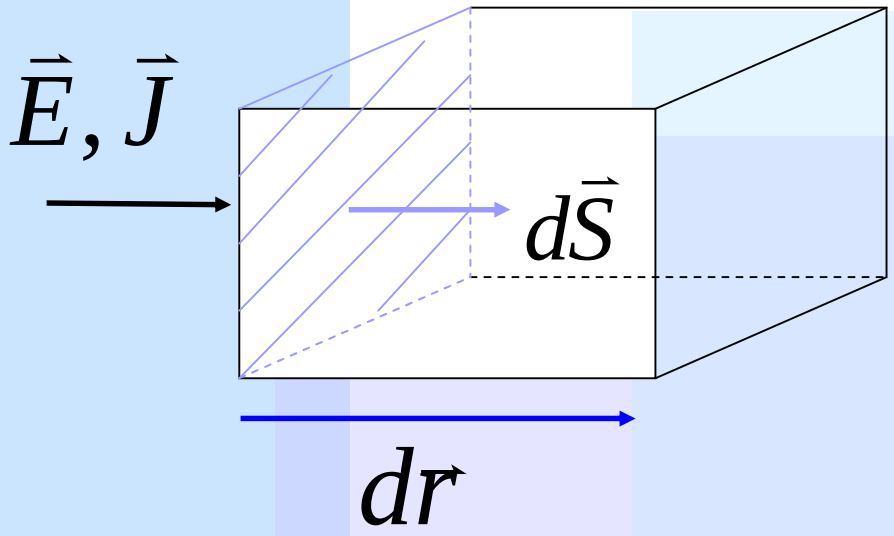
Potencia disipada

$$P = RI^2$$

$$P = \frac{\pi}{2gbh_2}\left(h_1 + \frac{h_2}{2}\right)I^2$$



Efecto Joule



$$dP = I\Delta V$$

$$dP = \underbrace{\left(\vec{J}\cdot d\vec{S}\right)}_{I}\cdot\underbrace{\left(\vec{E}\cdot d\vec{r}\right)}_{\Delta V}$$

$$\Rightarrow dP = \vec{J}\cdot\vec{E}\cdot d\vec{s}\cdot d\vec{r}$$

Se cumple

$$d\vec{s}\cdot d\vec{r} = dv \Rightarrow dP = \vec{J}\cdot\vec{E}\cdot dv$$

Potencia disipada en volumen Ω

$$\therefore \quad P = \iiint_{\Omega} \vec{J}\cdot\vec{E}\, dv$$

Ejemplo

Densidad de corriente

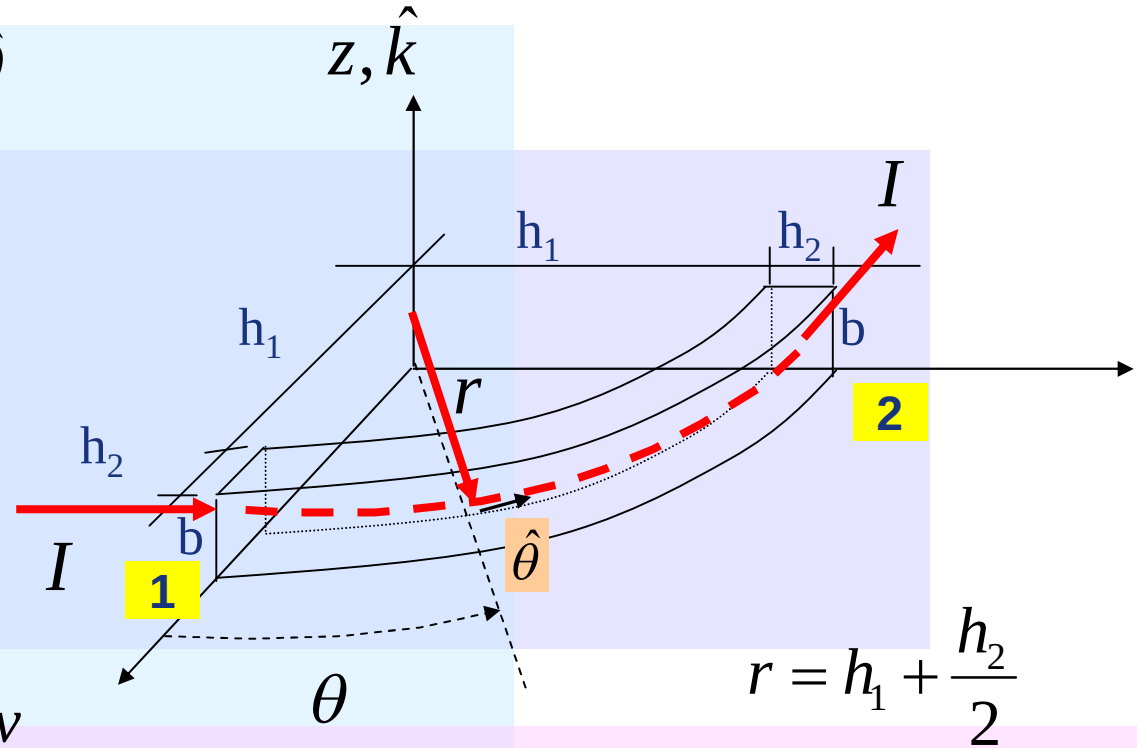
$$\vec{J}(\vec{r}) = \frac{I}{bh_2}\hat{\theta}$$

Campo

$$\vec{E}(\vec{r}) = \frac{I}{gbh_2}\hat{\theta}$$

Potencia disipada

$$P = \iiint_{\Omega} \vec{J} \cdot \vec{E}\, dv$$



$$r = h_1 + \frac{h_2}{2}$$

$$P = \iiint_{\Omega} \frac{I}{bh_2}\hat{\theta} \cdot \frac{I}{gbh_2}\hat{\theta}\, dv$$

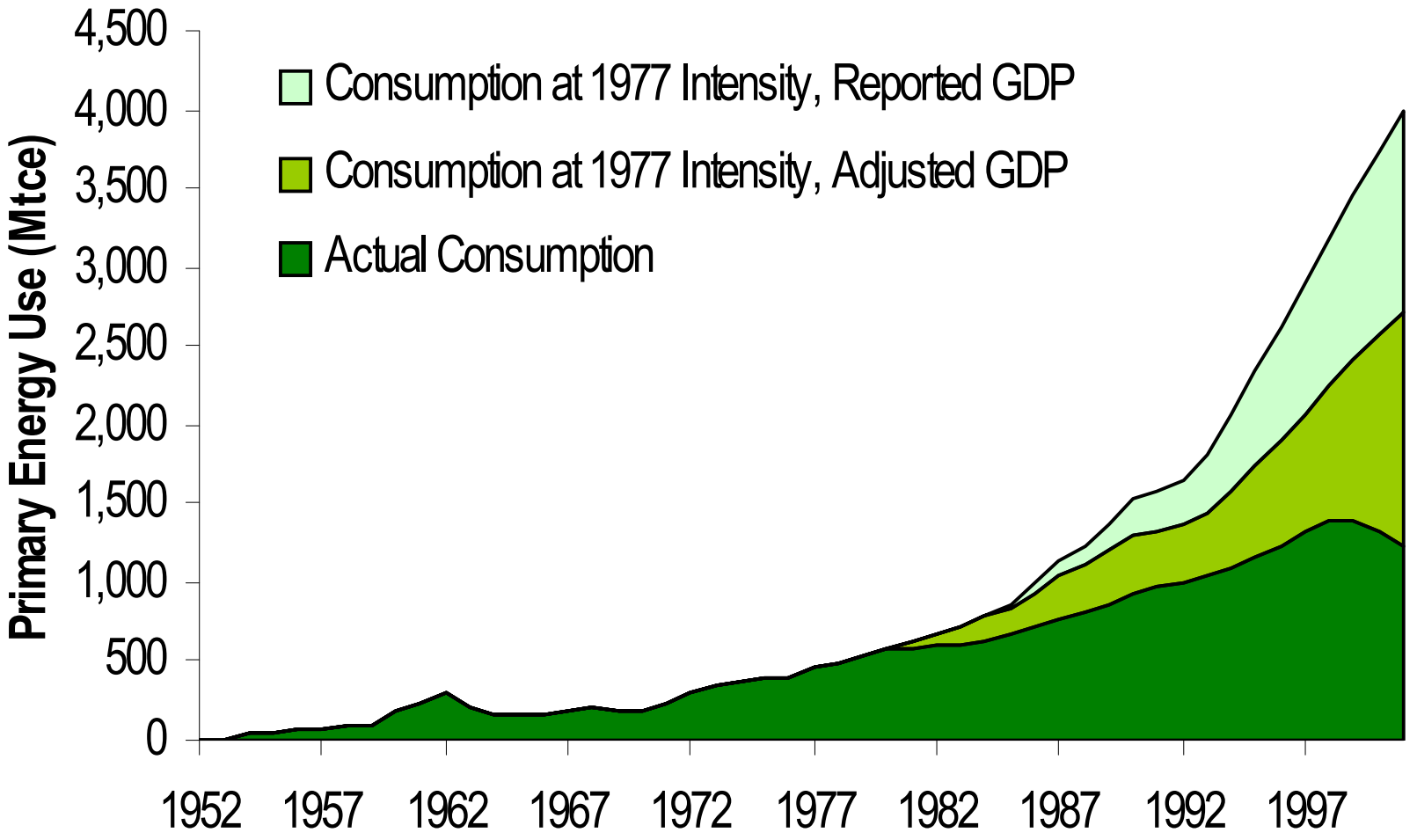
$$P = \frac{I}{bh_2} \cdot \frac{I}{gbh_2} \iiint_{\Omega} dv = \frac{I^2}{g\left(bh_2\right)^2} bh_2 \frac{2\pi r}{4}$$

$$P = \frac{\pi}{2gbh_2}\left(h_1 + \frac{h_2}{2}\right) I^2$$

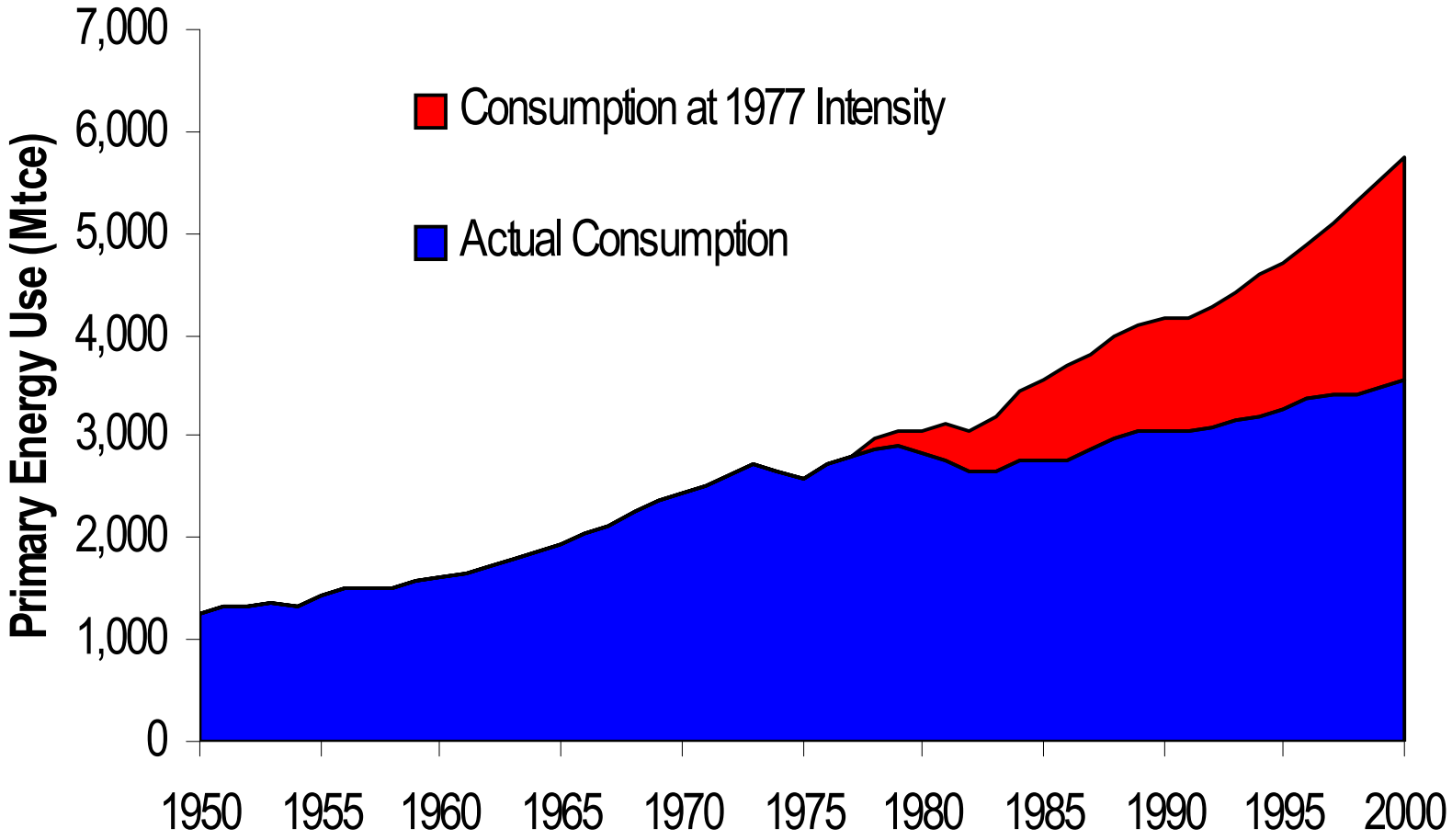
Aspectos prácticos del efecto Joule

- Calentamiento indeseado de máquinas eléctrica
- Calentamiento de artefactos produce incendios
- Pérdidas de energía en general
- La eficiencia energética es un tema país

China's energy intensity

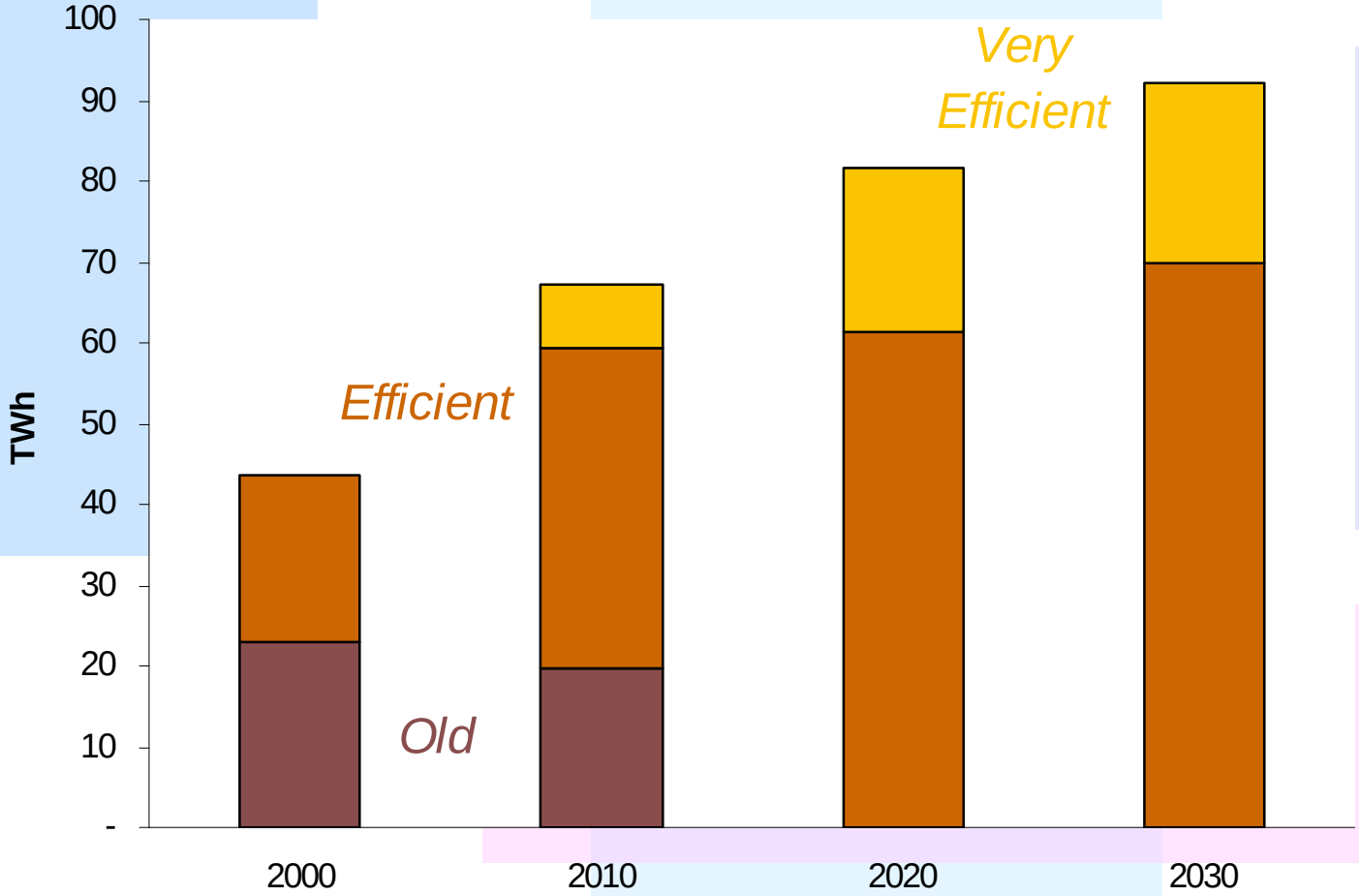


USA's energy intensity

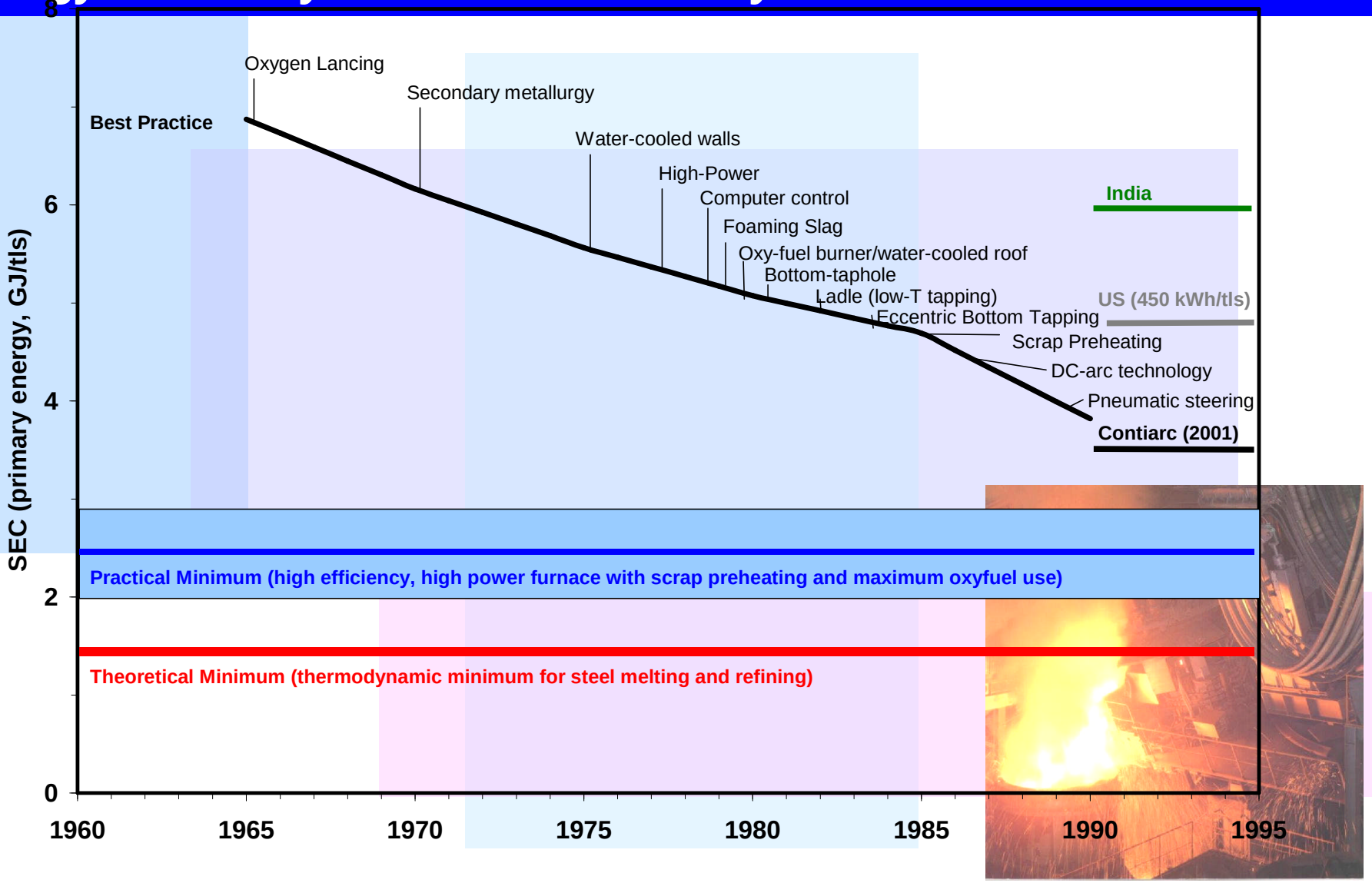


CHINA

China 3.5% Case: Urban Refrigerators



Energy Efficiency in the Steel Industry – Electric Arc Furnace



Ingeniería Eléctrica
FACULTAD DE CIENCIAS
FÍSICAS Y MATEMÁTICAS
UNIVERSIDAD DE CHILE

Eficiencia Energética en Chile