Lecture 37 outline: 11/13/2020

- Conductivity and Resistivity
- Ohm's Law
- Drude Model of conductivity

- Next time ---
- Boundary conditions / Current sheet
- Questions!

Current

$$I \stackrel{\text{def}}{=} \frac{\Delta Q}{\Delta t} \qquad I = \lambda \vec{v}$$

$$I \stackrel{\text{def}}{=} \vec{J} \cdot \vec{A} \qquad \vec{J} = \rho \vec{v} = Nq \vec{v}$$

Current Density … what's J?

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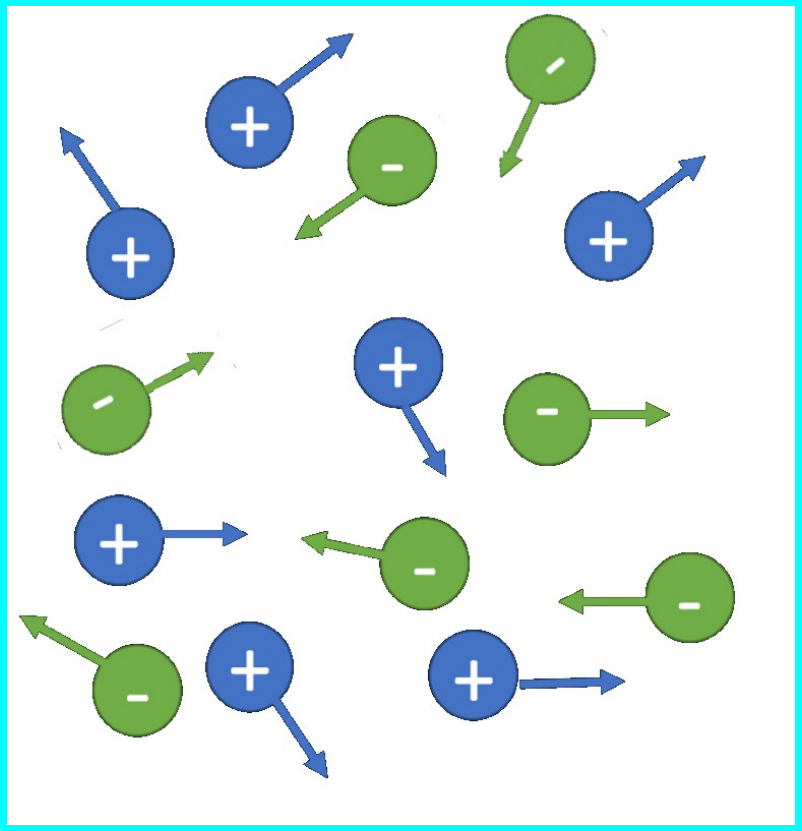


Resistivity/Conductivity and Ohm's Law

Ohm's Law

$$\vec{J} = \sigma \vec{E} = \frac{\vec{E}}{\rho}$$

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

$$V = I R$$

Clicker

$\vec{J} = \sigma \vec{E}$

σ represents:

A) Surface charge density

B) Volume charge density

C) Resistivity

D) Conductivity

Clicker

$\vec{J} = \rho \vec{v}$

ρ represents:

A) Surface charge density

B) Volume charge density

C) Resistivity

D) Conductivity

Clicker

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

ρ represents:

A) Surface charge density

B) Volume charge density

C) Resistivity

D) Conductivity

Drude Model of Conductivity

Drude Conductivity of Lithium

Number density: $N = \frac{3.53 \times 10^{28}}{m^3}$

Collision time: $\tau = 2.8 \times 10^{-15}\,s$

Atomic Mass: $m = 1.17 \times 10^{-26}\,kg$ (3 protons, 4 neutrons)

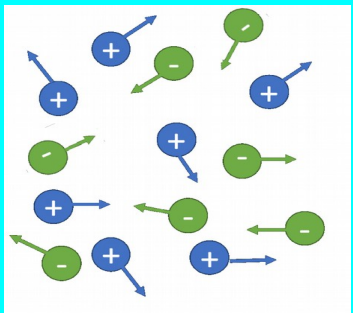
Resistance of a spool of wire

American Wire Gauge (AWG)

Table

AWG	Diameter		Turns of wire, without insulation		Area		Copper wire				
							Resistance/length[7]		Ampacity of enclosed wire at 30 °C ambient,[8] for given insulation material temperature rating, or for single unbundled wires in equipment for 16 AWG and smaller[9]		
									60 °C	75 °C	90 °C
	(in)	(mm)	(per in)	(per cm)	(kcmil)	(mm^2)	(mΩ/m[a])	(mΩ/ft[b])	(A)		
17	0.0453	1.150	22.1	8.70	2.05	1.04	16.61	5.064			
18	0.0403	1.024	24.8	9.77	1.62	0.823	20.95	6.385	10	14	16
19	0.0359	0.912	27.9	11.0	1.29	0.653	26.42	8.051	—	—	—
20	0.0320	0.812	31.3	12.3	1.02	0.518	33.31	10.15	5	11	—
21	0.0285	0.723	35.1	13.8	0.810	0.410	42.00	12.80	—	—	—
22	0.0253	0.644	39.5	15.5	0.642	0.326	52.96	16.14	3	7	—
23	0.0226	0.573	44.3	17.4	0.509	0.258	66.79	20.36	—	—	—
24	0.0201	0.511	49.7	19.6	0.404	0.205	84.22	25.67	2.1	3.5	—
25	0.0179	0.455	55.9	22.0	0.320	0.162	106.2	32.37	—	—	—
26	0.0159	0.405	62.7	24.7	0.254	0.129	133.9	40.81	1.3	2.2	—
27	0.0142	0.361	70.4	27.7	0.202	0.102	168.9	51.47	—	—	—
28	0.0126	0.321	79.1	31.1	0.160	0.0810	212.9	64.90	0.83	1.4	—
29	0.0113	0.286	88.8	35.0	0.127	0.0642	268.5	81.84	—	—	—
30	0.0100	0.255	99.7	39.3	0.101	0.0509	338.6	103.2	0.52	0.86	—
31	0.00893	0.227	112	44.1	0.0797	0.0404	426.9	130.1	—	—	—
32	0.00795	0.202	126	49.5	0.0632	0.0320	538.3	164.1	0.32	0.53	—
33	0.00708	0.180	141	55.6	0.0501	0.0254	678.8	206.9	—	—	—
34	0.00630	0.160	159	62.4	0.0398	0.0201	856.0	260.9	0.18	0.3	—
35	0.00561	0.143	178	70.1	0.0315	0.0160	1079	329.0	—	—	—

A 12 Volt battery is put across a 2 meter long tube of sea water. What is v_drift?



Ch 5 Questions:

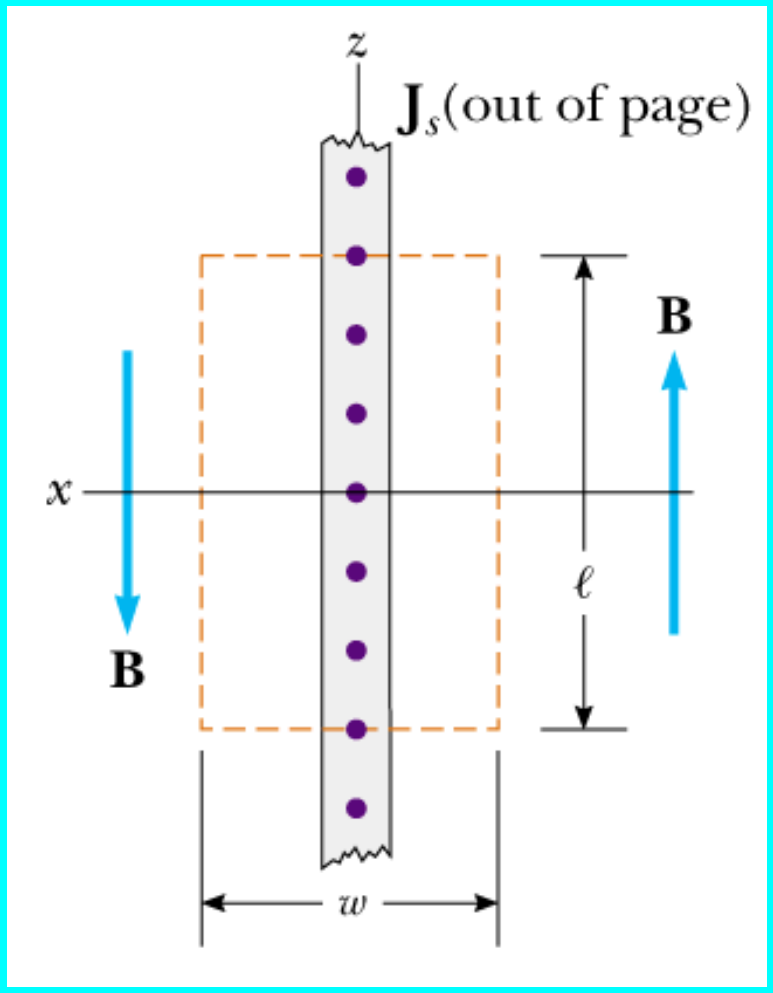
Magnets snap together. How can you say B does no work? (Edelman)

- Magnetic forces change particle's direction, how can this not do work?
- What's going on on p 218?
- Is Lorentz force really "empirical"?
- Is there magnetic potential energy? (Reed)
- J? (Taylor)
- What is relativistic Lorentz Force? (Smith)
- Is f_electrostatic E? (Privett)
- Why does Griffith's call water an insulator? (Sahd)
- How can you say E=0 in a conductor? (Pedrozza, Kelso, Gandarilla)
- Is there magnetic potential energy?

Lorentz Force $\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$

B does no work?

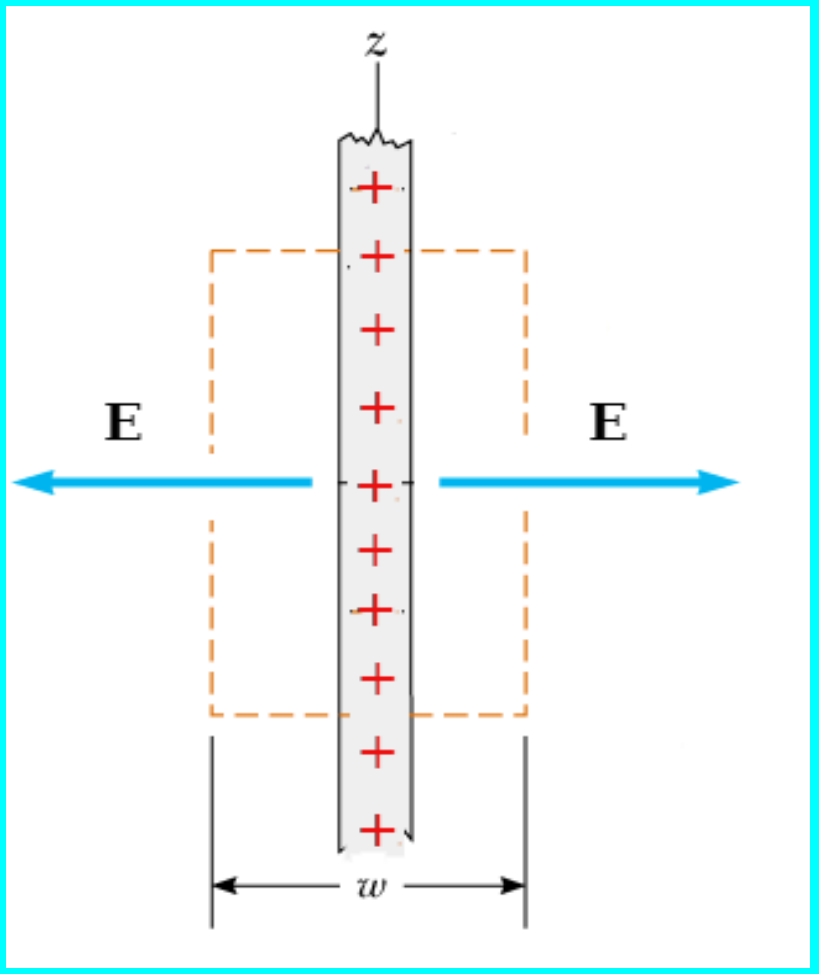
Infinite Current Sheet



$$\Delta B_{\parallel} = \mu_0 J t$$

$$\Delta B_{\parallel} = \mu_0 K$$

Infinite Charge Sheet

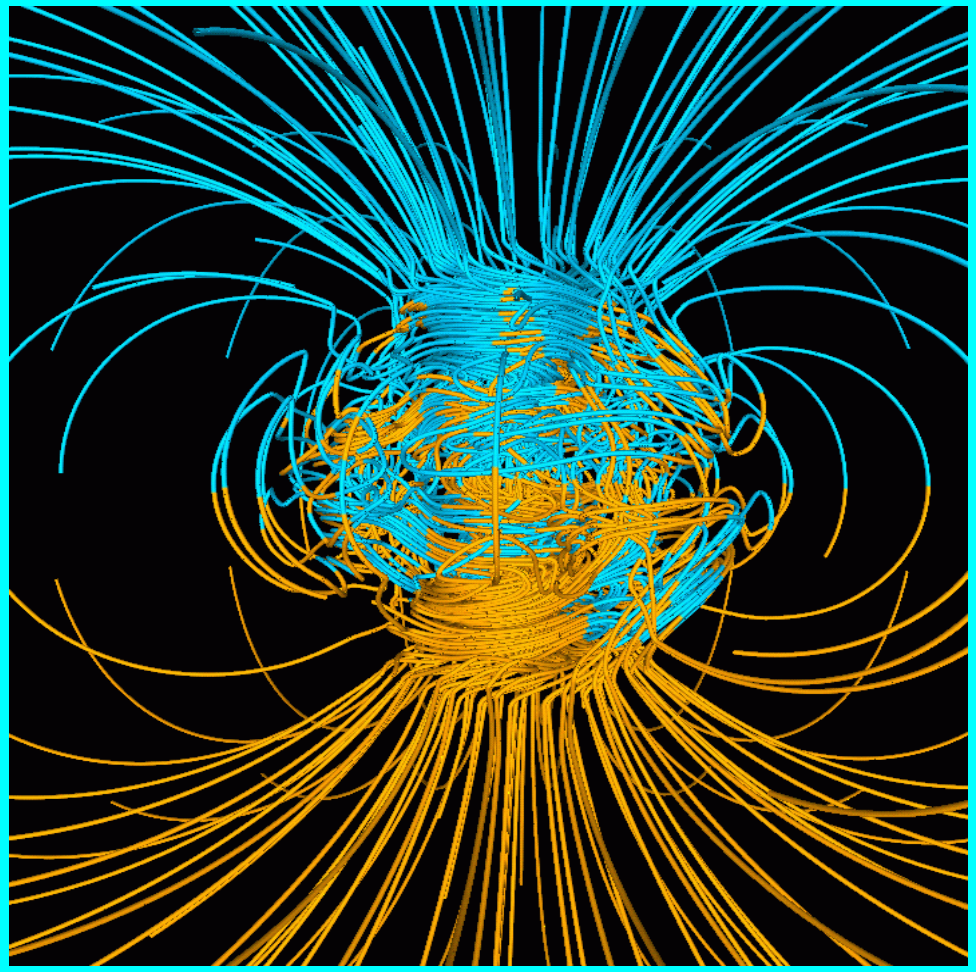


$$\Delta E_n = \frac{\sigma}{\epsilon_0}$$

Cyclotron motion / Aurora

$$\vec{F} = q\,\vec{v} \times \vec{B}$$

https://www.nasa.gov/mission_pages/sunearth/aurora-videos/index.html



Maxwell's Equations

Gauss's Law

$$\oiint \vec{E} \cdot d\vec{a} = \frac{Q}{\epsilon_0}$$

$$\nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$

The "no monopole" equation

$$\oiint \vec{B} \cdot d\vec{a} = \mu_0 Q_{\text{monopole}} = 0$$

$$\nabla \cdot \vec{B} = 0$$

Ampere's Law

$$\oint \vec{B} \cdot dl = \mu_0 I$$

$$\nabla \times \vec{B} = \mu_0 \vec{J}$$

Faraday's Law

$$\varepsilon = -\frac{\partial}{\partial t} \int \vec{B} \cdot d\vec{a}$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$