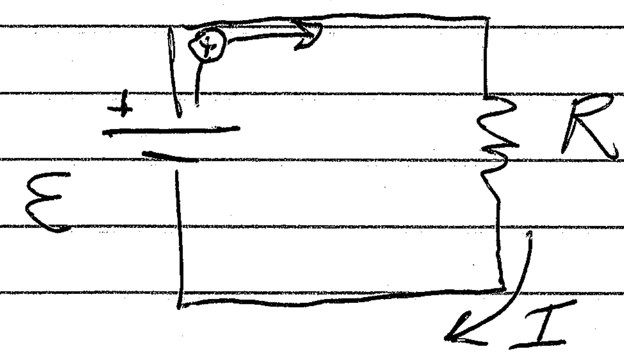
 Phys 2426 2015-09-15 Lec 6

Syllabus/Schedule Update! (Posted on web folder)

HW2 Thu 9/24

Exam1 Tue 9/29



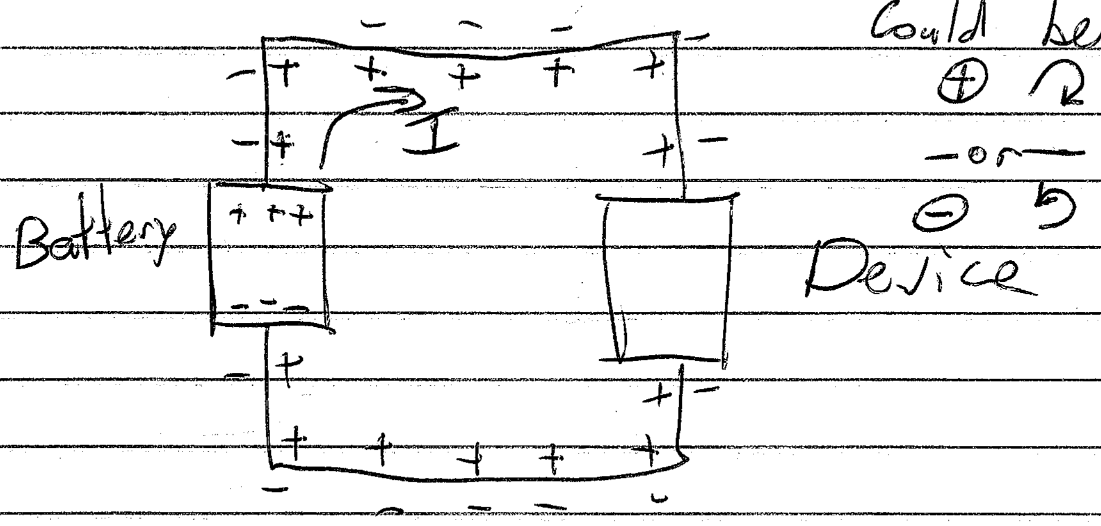
Apply a voltage $\mathcal{E}$ to a resistor R, current I flows.

Ohm's Law: $V = IR$

V = voltage across resistor ($\mathcal{E}$ above)
R = resistance (const if "Ohmic")
I = current that flows

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

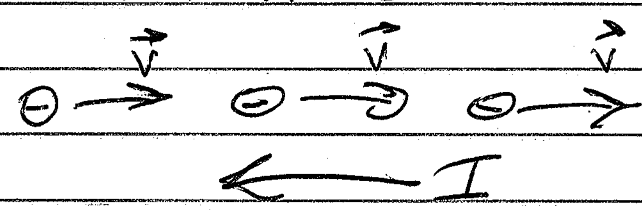
Easy to have $I = 1.0\ A$
But having $Q = 1.0\ C$ is crazy.



Charges are balanced.
Current is the flow of one (or the other) type of charge.

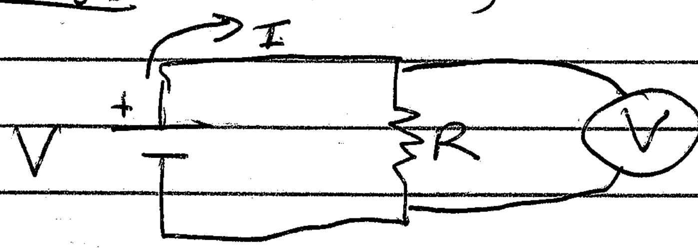
⊕ charges form current in the same dir they flow.

⊖ charges form current opposite to their flow.



Measuring w/o Disturbing

Voltage: Working Circuit

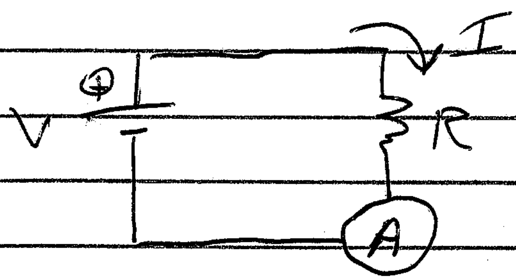


To measure V, the meter has no I.

$$V = I_m R_m$$

Voltmeter has huge R_m.

Current: Must break the circuit

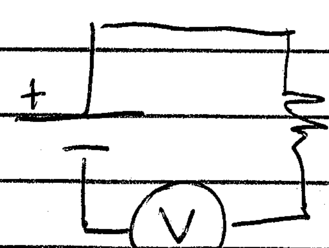


Ammeter is part of the current path.

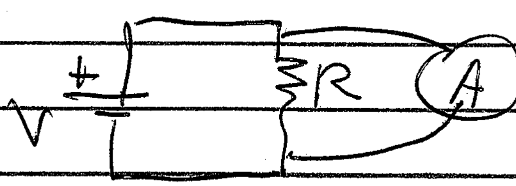
To measure I, the meter uses no V.

$$V = I R_m$$

The Ammeter must have a tiny R_m.



Wrong! Current cannot flow!



Wrong! Lots of current flows!

(4) Power is the flow of Energy

$$P = \frac{\text{Energy}}{\Delta t} = \frac{\text{Charge}}{\Delta t} \frac{\text{Energy}}{\text{Charge}}$$

$$P = IV$$
$$V = IR$$

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

Out of 4 variables, we have 2 non-redundant equations. Need 2 values.

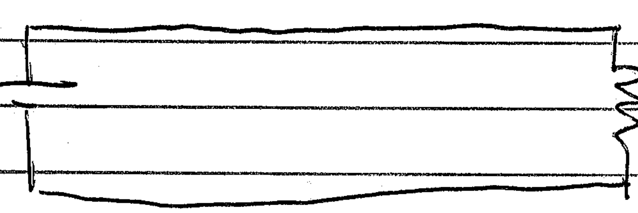
Ex: 60 W Light bulb designed for 120 V electrical outlet.

$$P = 60\ W$$
$$V = 120\ V$$

$$(60W) = (120\ V)\ I \qquad I = 0.5\ A$$
$$(120V) = (0.5A)\ R \qquad R = 240\ \Omega$$

$P = I^2 R$ is power lost in a wire

$P = IE$

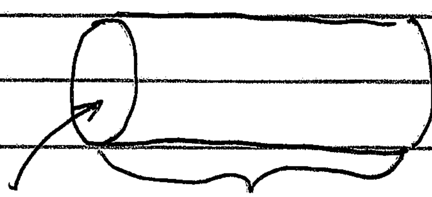


$P_R = I^2 R = I V_R$

$P_W = I^2 R_W$

Physics of Flow

Consider the water in a pipe



Area $= A$ $\quad l = v\Delta t$

$$Vol = A l = A v \Delta t$$

$$\text{Vol Flow Rate} = \frac{Vol}{\Delta t} = A v$$

$$\text{Mass Flow Rate} = \rho A v$$

$\rho =$ density $=$ mass / Vol

$$\text{Particle Flow Rate} = \frac{Count}{\Delta t} = \eta A v$$

$\eta =$ particle density $=$ count / Vol

$$\text{Charge Flow Rate} = I = e \eta A v$$

Ex: $\eta = 10^{28}\ m^{-3}$ "carrier density"

$e = 1.6 \times 10^{-19}\ C$

$A = \pi (0.001\ m)^2$

$I = 1.0\ A$

$$v = 0.0002\ m/s = 0.2\ mm/s = 12\ \frac{mm}{min}$$

This is the "Drift Velocity".

(6)

People Flow Rate $= \frac{\text{People}}{s} = \rho v \cancel{A} w$

ρ = Density in people $/m^2$
v = walking speed
w ~~A~~ = width of doorway

Resistivity: $R = \rho \frac{l}{A}$

ρ ← resistivity in $(\Omega \cdot m)$

Thermal Coefficient

$$R = R_0 \left(1 + \alpha (T - T_0)\right)$$

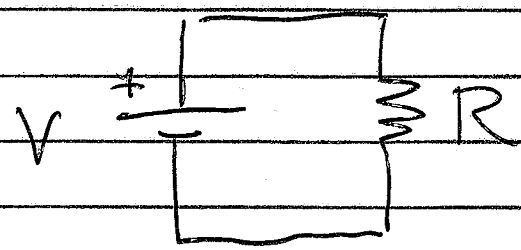
$$\frac{R}{R_0} = 1 + \alpha (T - T_0)$$

$$\frac{R}{R_0} - \frac{R_0}{R_0} = \alpha (T - T_0)$$

$$\frac{R - R_0}{R_0} = \alpha (T - T_0)$$

$$\frac{\Delta R}{R_0} = \alpha \Delta T$$

$\alpha = 0.01 \ {}^\circ F^{-1}$ means 1% per ${}^\circ F$



$I = \frac{V}{R}$

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

Power heats the resistor.

If α is ⊕: $\frac{\Delta R}{R_0} = \alpha \Delta T$

ΔR is ⊕
R increases
P decreases
System finds equilibrium

If α is ⊖: ΔR is ⊖
R decreases
P increases
System heats more!
Thermal Runaway.