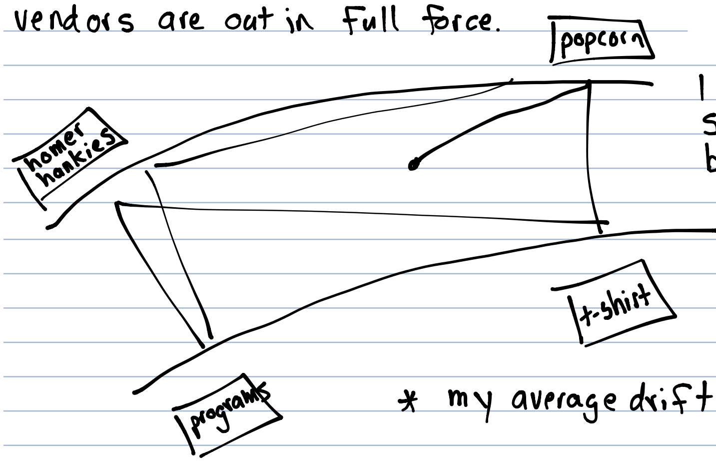
Current & Resistivity

Setting: The Metrodome (Minneapolis)
Oct 1987
3 hours before Game 2 of WS

I'm the only fan wandering the stadium corridors. But of course the vendors are out in full force.



I frantically try to snap up every souvenir possible, and food items, before the hordes arrive.

My typical unimpeded speed is 10^6 m/s *

2 hours later, the crowd arrives.

* my average drift velocity is $v_d \sim 0$ m/s

The 1^{st} pitch nears; I frantically make my way to my seat.

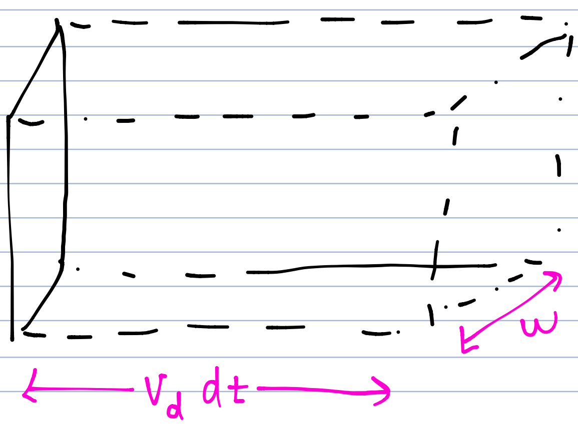
I'm finding it difficult to make my way

m V_d is now $\sim 10^{-4}$ m/s, but I'm still moving at 10^6 m/s

The "field" pushes me to my seat.

The "people current" – how many people pass thru a door of width w in time dt

area A of door



people in this volume

is $\frac{\text{people}}{\text{volume}} \cdot$ volume

$= \frac{\text{people}}{\text{volume}} \cdot V_d\,dt\,A$

$\Rightarrow$ people/time = people current

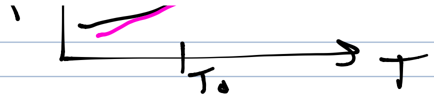
$= \frac{\text{people}}{\text{volume}} \cdot V_d \cdot A$

at the atomic level, faster speed $\Leftrightarrow$ increased T

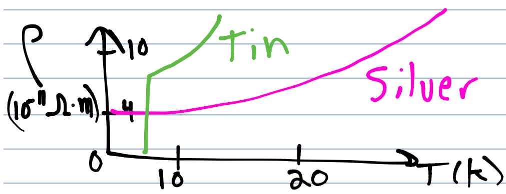
$\rho(T) \propto$ change in T: $\rho(T) = \rho_0 + \rho_0\,\alpha\,(T - T_0)$

$\rho \uparrow$

The relation isn't perfectly linear, but it's a



good approximation for most T



$T_{critical}$ for S_b is ~4K

Q: Why does a light bulb turn on "instantly", thoug $v_d \sim 10^{-4}$ m/s?

A: Only need e^- at one end to move just into the wiring (think of water filling a hose)

Resistivity and Resistance

Resistance $R \propto \rho$

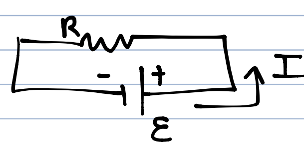
Resistance $R \propto L$ length

Resistance $R \propto \frac{1}{A}$ $\longrightarrow R = \frac{\rho L}{A}$

Also, think of "how much flow" vs "how much push"

Ohm's Law $R = \frac{V}{I}$

DC circuits



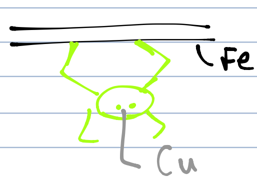
R = resistance of resistor
ε = potential provided by battery
I = current

$I = \varepsilon / R$

Q: How does a battery provide a potential difference?

A: chemical reactions occur that separate charges

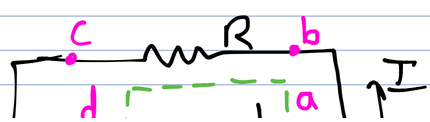
Luigi Galvani in 1786 suspended a frog from an iron rod



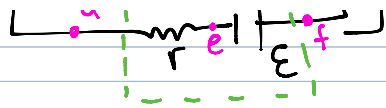
induced muscle twitching

→ discovered frogs are moist conductors

A more realistic circuit:



Important rule: if a charge starts at one location, traverses the circuit and returns



to its starting point, then $\sum \Delta V = 0$

→ total change in electrical P.E. is zero

$V_a = \varepsilon$

$V_b = V_a = \varepsilon$

$V_c = V_b - IR = \varepsilon - IR$

$V_d = V_c = \varepsilon - IR$

$V_e = V_d - Ir = \varepsilon - IR - Ir$

$V_f = V_e + \varepsilon = 2\varepsilon - IR - Ir$

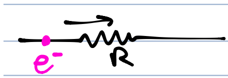
Also, $V_f = V_a = \varepsilon \Rightarrow 2\varepsilon - IR - Ir = \varepsilon \Rightarrow I = \frac{\varepsilon}{R+r}$

Concept Q ch09/s1.html (A)

$R_{Biff} = \frac{V}{I} = 20V/20mA = 1000\,\Omega$

$100mA \cdot 1000\Omega = V = 100\,V$

Power energy is transferred when a current passes through a resistor. But at what rate?



Work to push charge through $\Delta V\, dq$

$d\,Power = \frac{dW}{dt} = \frac{\Delta V\, dq}{dt} = \Delta V \frac{dq}{dt} = \Delta V I$

$P = IV = I(IR) = I^2R = V^2/R$

ch09/s2.html (B)

$V =$ same $\quad P_{100}/P_{50} = 2 = \frac{V^2/R_{100}}{V^2/R_{50}} = R_{50}/R_{100}$

ch09/s3html (A)

They have the same current, so use $P = I^2R$

$P_{50}/P_{100} = \frac{I^2R_{50}}{I^2R_{100}} = \frac{R_{50}}{R_{100}} = 2$

25.29 • When switch S in **Fig. E25.29** is open, the voltmeter V reads 3.08 V. When the switch is closed, the voltmeter reading drops to 2.97 V, and the ammeter A reads 1.65 A. Find the emf, the internal resistance of the battery, and the circuit resistance R. Assume that the two meters are ideal, so they don't affect the circuit.

Figure **E25.29**