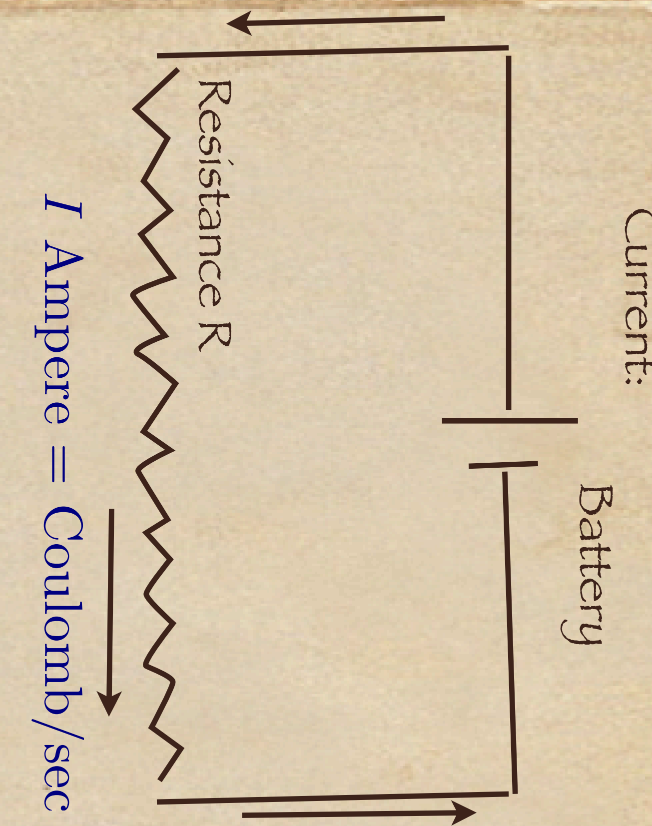
Lecture 14

May 2, 2012

Moving charges give currents: electrodynamics



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

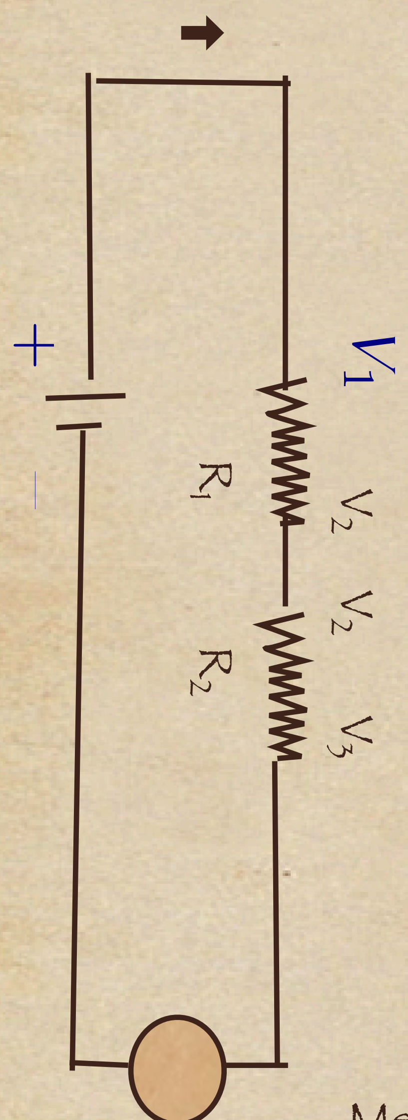
Useful Analogy: Charge "Q" is the total quantity of water in a tank.

Current "I" is the amount of water flowing through a pipe per second

Unlike charge, the current has a direction. We may speak of Q as a scalar and I as a vector.

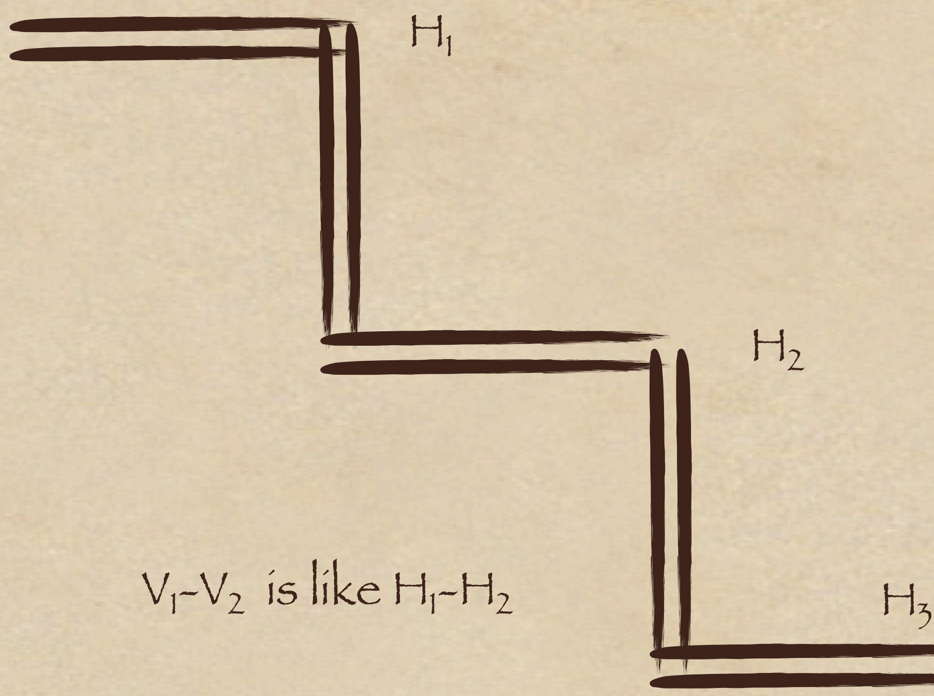
Example1: 100 Coulombs in 10 seconds gives a current of 10 amperes

Example2 : A bulb has a flow of 1 amp and is used for 10 minutes. Total charge = 600 seconds x 1 ampere = 600 Coulombs



Measures current
(Ammeter)

Water flow
in a terrace



V_1-V_2 is like H_1-H_2

V_2-V_3 is like H_2-H_3

Battery voltage is the total potential drop
$V = V_1 - V_3$

Water	Electricity
Total water in tank	Charge Q in battery [Coulomb]
Rate of flow of water in a pipe	Current I [Amperes]
Height of tank	Potential V [Volts]
Height difference	Potential difference
Constriction of pipe carrying water	Resistance R [Ohms]
Work done in forcing water through a pipe	Work done in pushing charge through a
Rate of doing work is power {watts}	Rate of doing work is power P {watts}

Voltage= potential difference

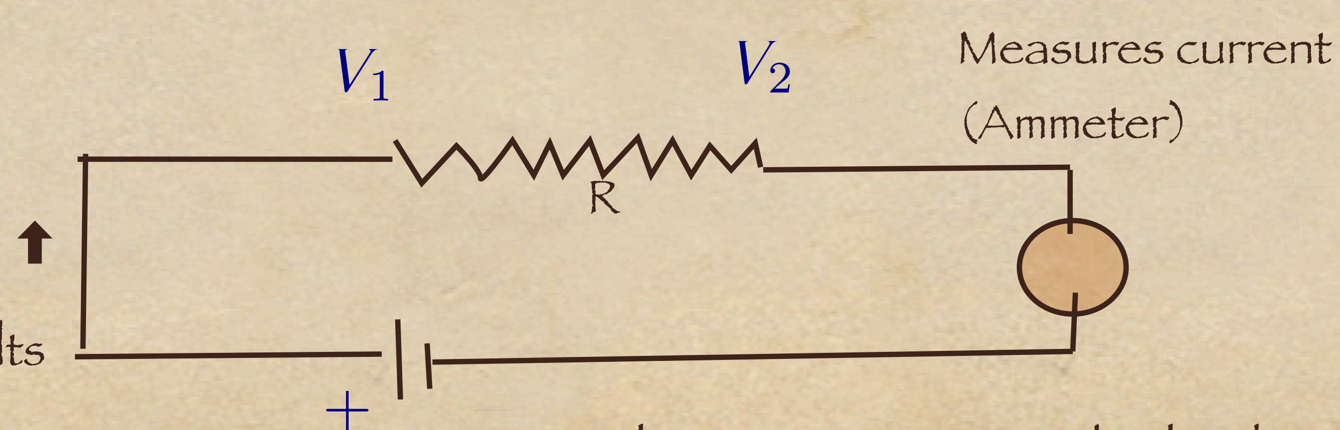
W= work done in moving a charge against a potential

$$V = V_1 - V_2$$

$$W = V \times Q$$

$$[V] = Joules/Coulomb$$

$$[V] = Volt$$

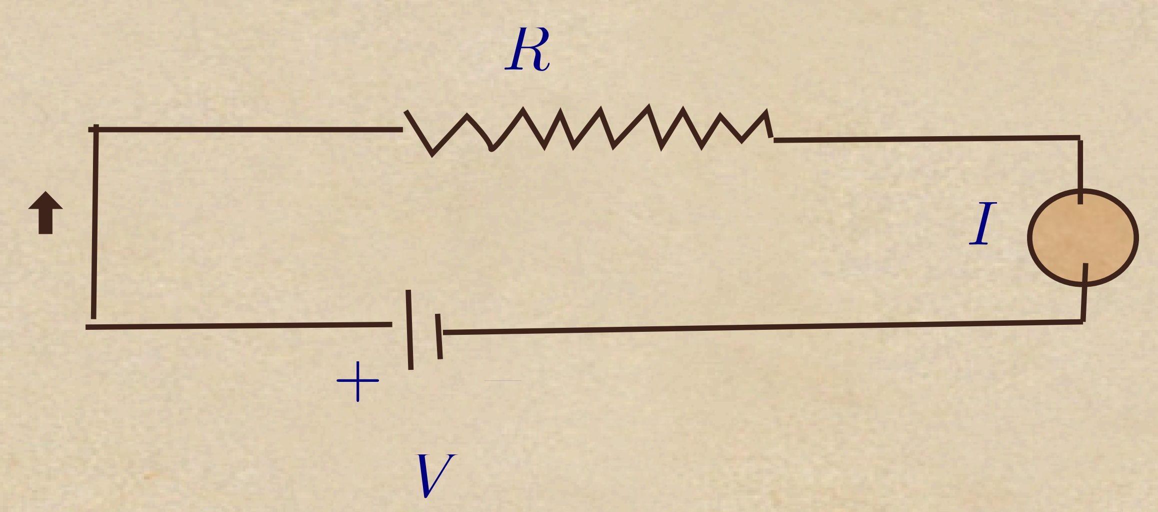


Car battery : 12 Volts

Cells: 1.5 Volts

Car battery passes 2 Coulombs charge doing 24 J work.

Resistance and Ohm's law



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

$$[R] = Ohms \;\rightarrow\; \Omega$$

$$[R] = \text{Volts/Ampere}$$

True for most metallic wires

R= resistance of the wire

Example : Battery 12 V, connect to resistance 1 Ohm gives current of 12 ampere.

by changing the resistance, we change the current in this situation

Work done and power relationship

Summarizing:

A) we saw that a charge Q can be moved against a voltage V and the work done is
$W= Q \times V$. Here Q is in Coulombs, V in volts, and W is in Joules (recall work done is dimensionally the same as energy.

B) We also saw that the current I is related to charge Q through
$I= Q/\Delta t$ where the variable Δt is the time interval during which Q flows.

C) Now recall that power P is the rate of doing work, i.e.
$P= W/\Delta t$. Hence
$P= QxV/\Delta t$

We now use the definition of current above and conclude that

$P= V \times I$
Here if we write V in volts and I in Coulomb per second (i.e. amperes) then P is automatically in Watts.

Current, Voltage, and Power redux

I Amperes

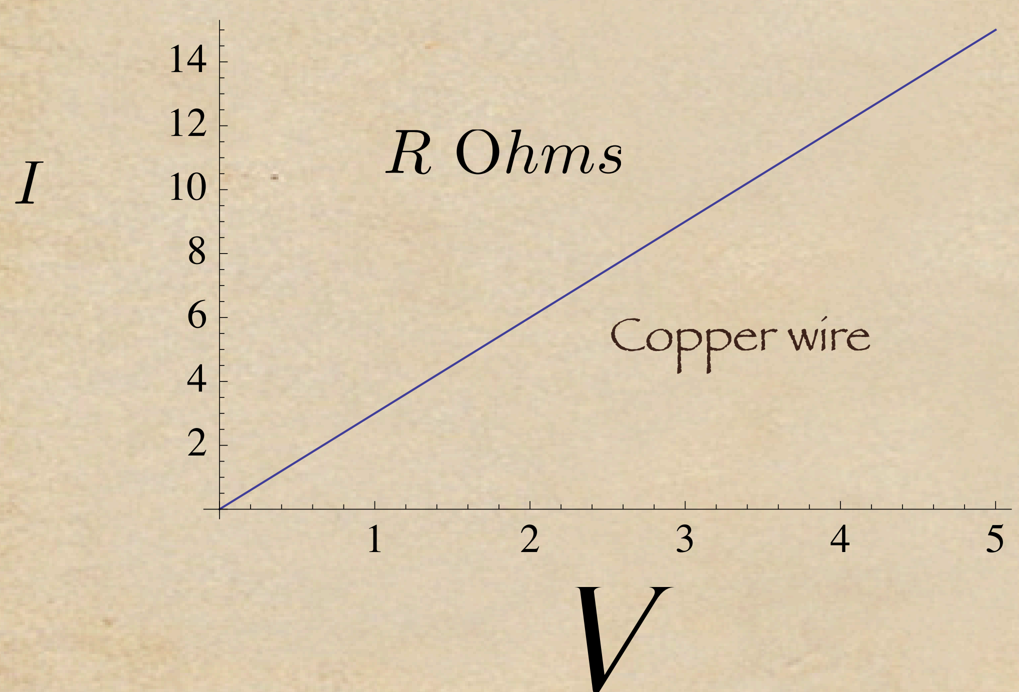
$$I = f(V)$$

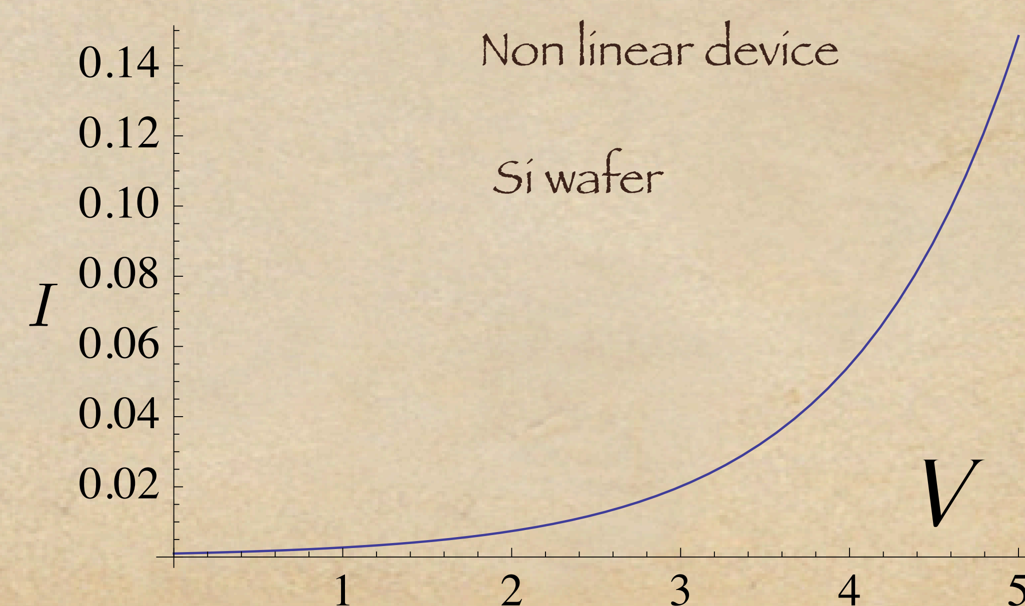
V Volts

$P = I\ V$ Power in Watts

V= I x R   Ohm's Law for resistances (Linear curves)

P= I^2 R for resistances





Now we do the quiz #2