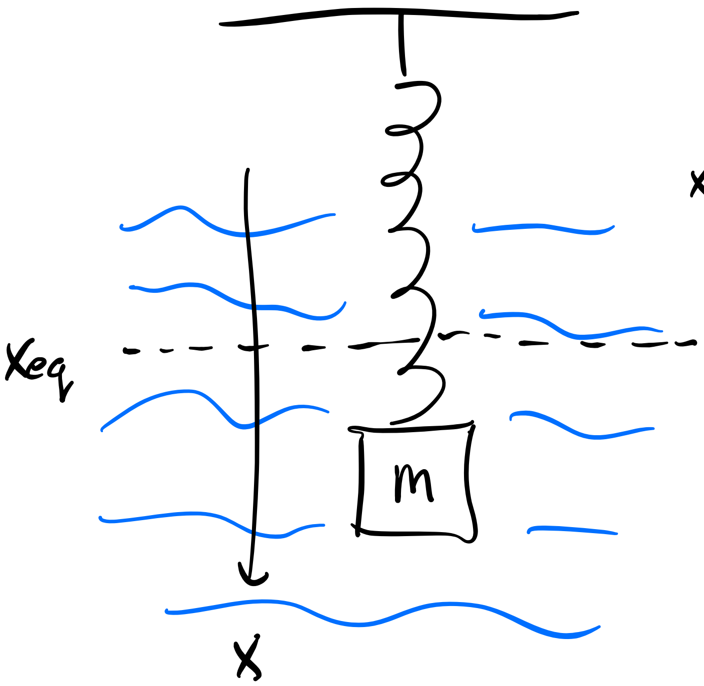
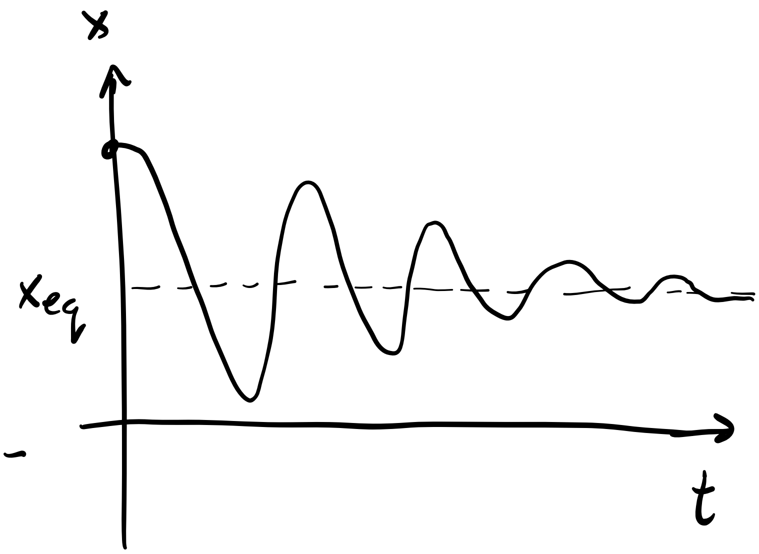
PHYS 231 - Sept. 27, 2023

Last Time:

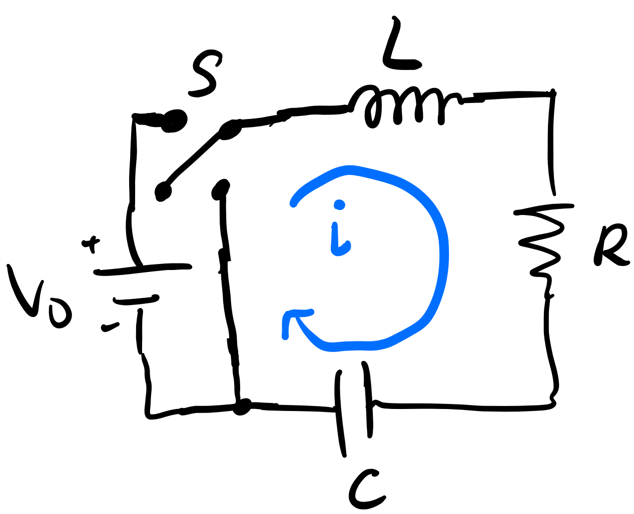




$$g = \frac{d^2x}{dt^2} + \frac{b}{m}\frac{dx}{dt} + \frac{k}{m}x$$

$$x_{eq} = mg/k$$

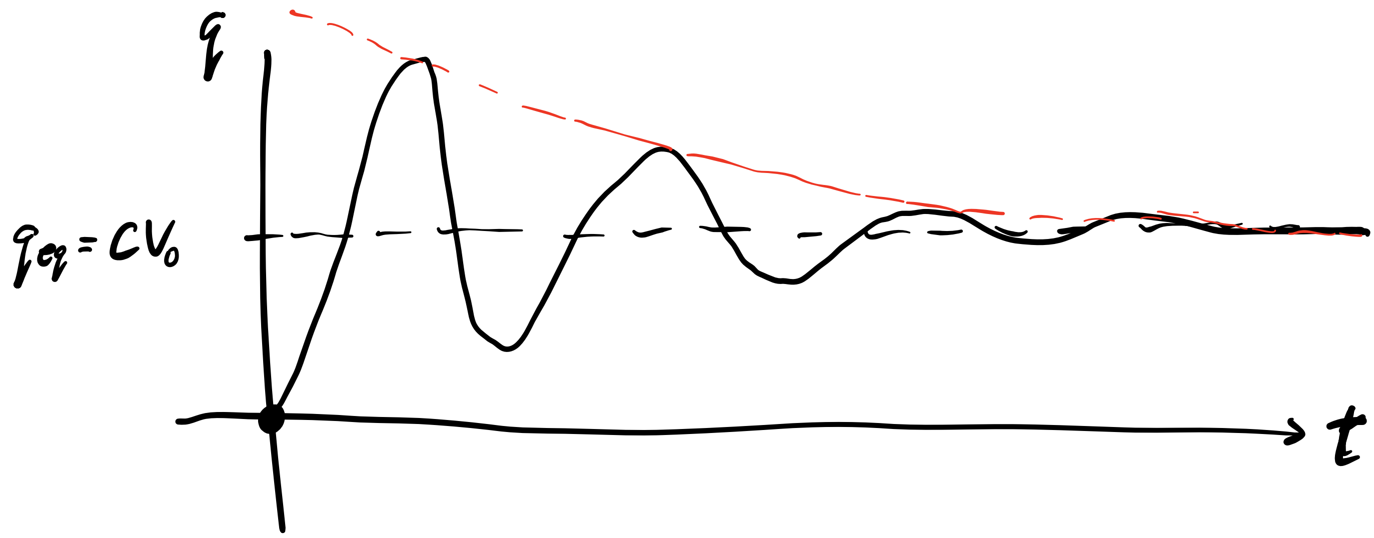
Series LRC Circuit



$$\frac{V_0}{L} = \frac{d^2q}{dt^2} + \frac{R}{L}\frac{dq}{dt} + \frac{q}{LC}$$

$$q_{eq} = CV_0$$

Get <u>underdamped</u> osc. when dissipative losses are low $\Rightarrow$ small R.



If $q = 0$ @ $t = 0$

For an LRC circuit, get underdamping when

$$\frac{R}{2L} < \frac{1}{\sqrt{LC}}$$

damped osc. decay away more slowly as R is decreased.

The solution for the charge on the capacitor in the LRC circuit is:

$$q(t) = CV_0 \left[1 - e^{-(\gamma/2)t} \cos(\omega_1 t) \right]$$

where $\gamma = \frac{R}{L}$

$$\omega_1 = \sqrt{\omega_0^2 - \left(\frac{\gamma}{2}\right)^2} \quad \omega_0 = \frac{1}{\sqrt{LC}}$$

To find the current in the LRC circuit, take the time derivative of the charge

$$i = \frac{dq}{dt} = CV_0 \left[\frac{\gamma}{2} e^{-(\gamma/2)t} \cos(\omega_1 t) + \omega_1 e^{-(\gamma/2)t} \sin(\omega_1 t) \right]$$

complicated!

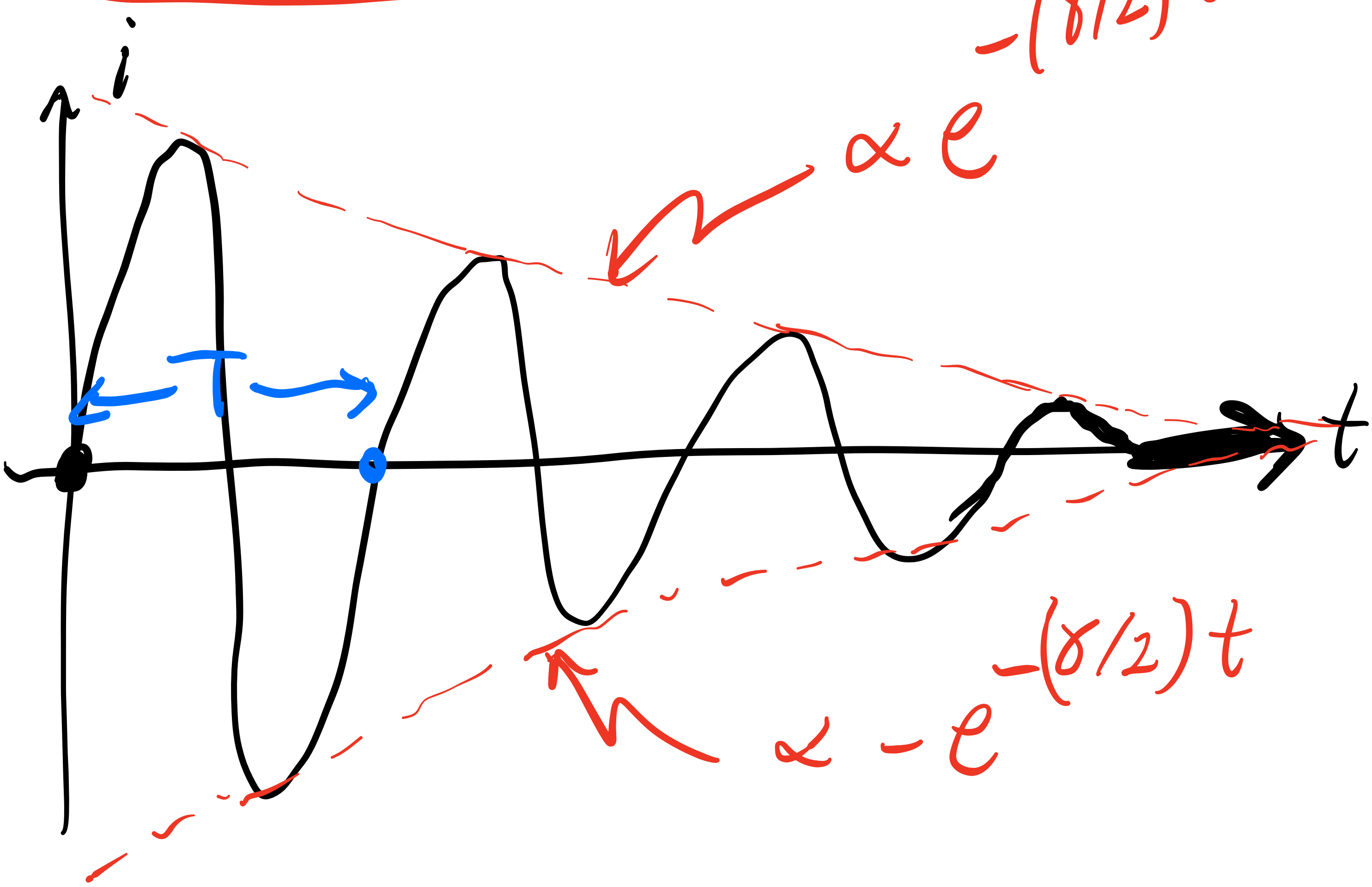
Because the first term in i has a pre-factor of $\gamma = R/L$, for a highly under-damped system (R small), the first term is negligible c.t. the second term.

Notice also that $\omega_1 = \sqrt{\omega_0^2 - \left(\frac{\gamma}{2}\right)^2}$

$\approx \omega_0$ when γ small.

$$i \approx \omega_0 C V_0 e^{-(\gamma/2)t} \sin(\omega_0 t)$$

where $\omega_0 = \frac{1}{\sqrt{LC}}$



In lab # 4, we will use an osc. to meas. a series LRC circuit. Osc. only meas. voltages.

We will meas. the voltage across the resistor in the LRC circuit.

$$V_R = iR = \omega_0 R C V_0 e^{-(\gamma/2)t} \sin(\omega_0 t)$$

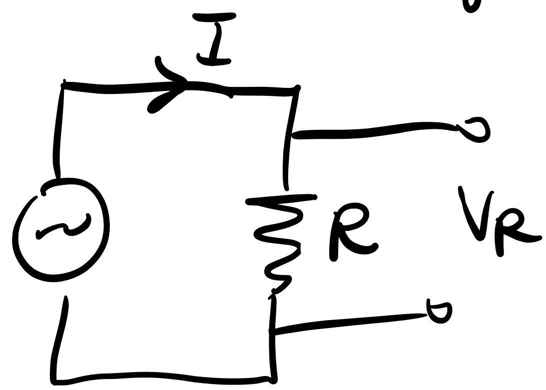
The period of osc. is the time to complete one full cycle.

$$\omega_0 = \frac{2\pi}{T} \rightarrow T = \frac{2\pi}{\omega_0} = 2\pi\sqrt{LC}$$

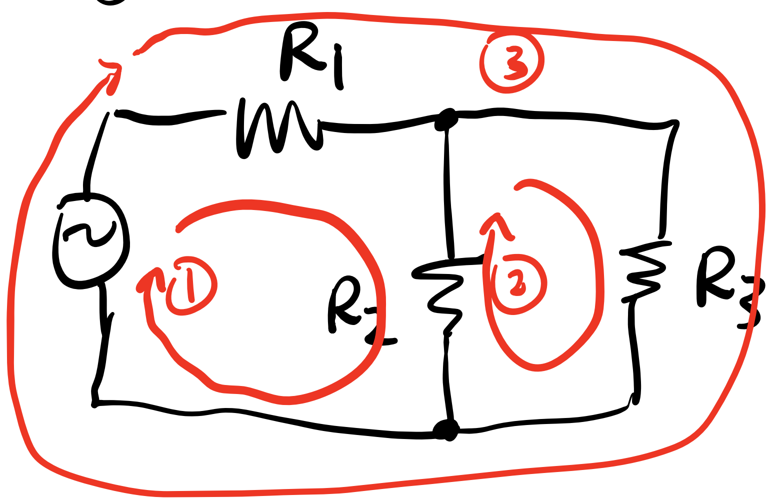
Lab # 4.

In Lab #2 tomorrow, you will:

① meas. current & voltage of a resistor



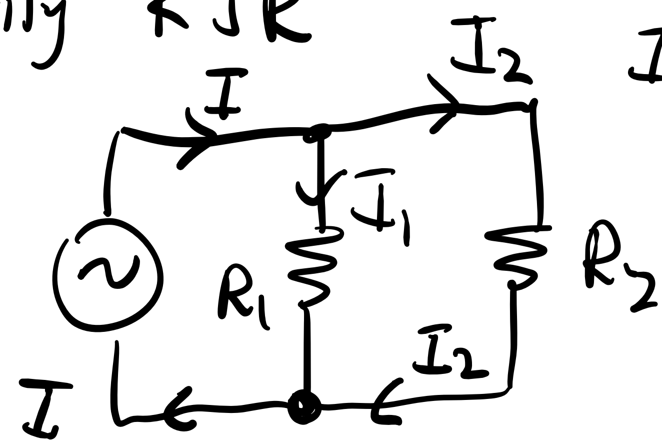
② Verify KVLR



③ Verify KJR

test if

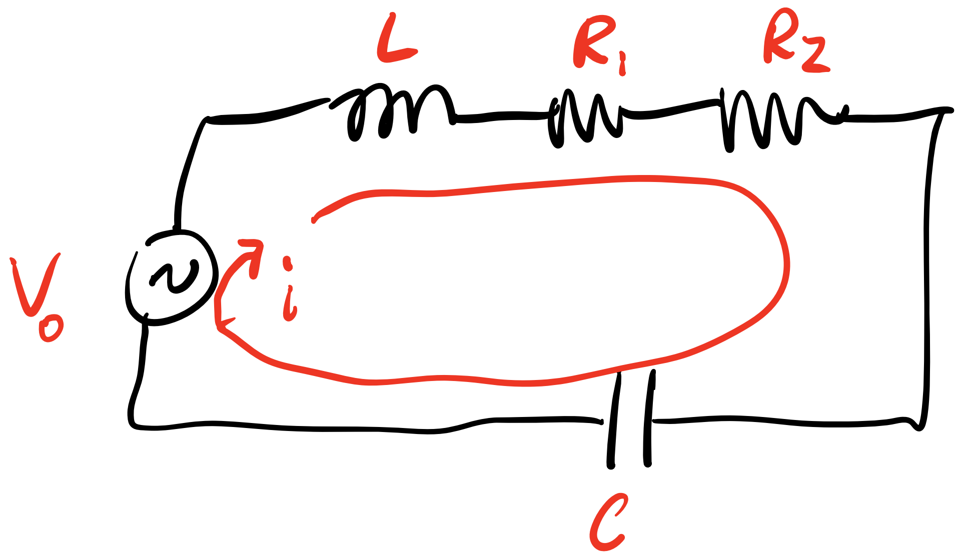
$I = I_1 + I_2$



Need to make voltage & current meas. to complete Lab #2.

Current Measurements

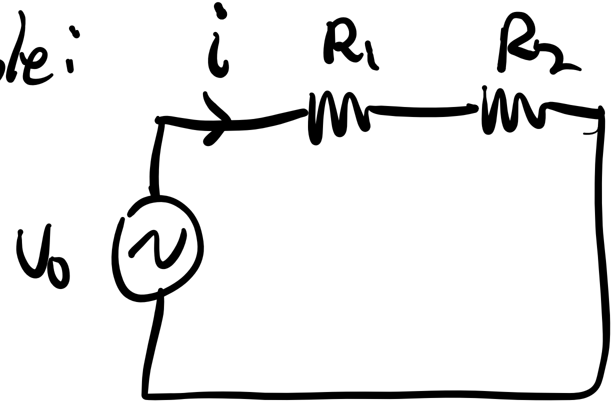
(*) Reminder: All components in series have the same current.



$$i_{V_0} = i_L = i_{R_1} = i_{R_2} = i_C \equiv i$$

To make a current meas., place the ammeter in series with the branch of the circuit we want to meas.

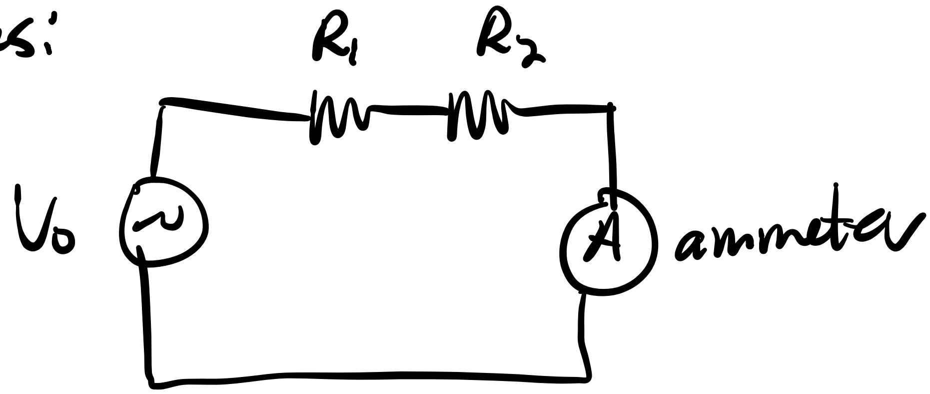
Example:



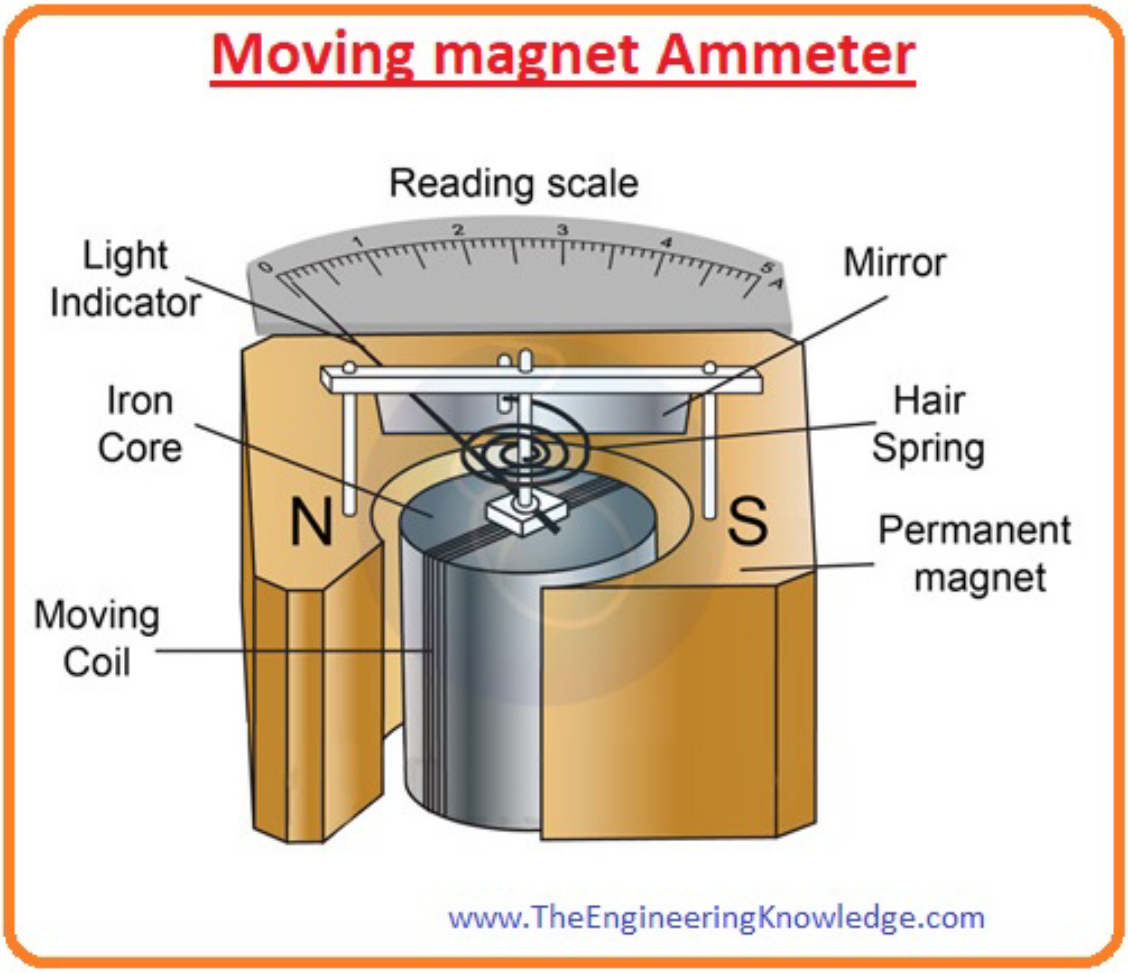
Expect

$$i = \frac{V_0}{R_1 + R_2}$$

Meas:



Have to break a branch of the circuit to insert the ammeter.



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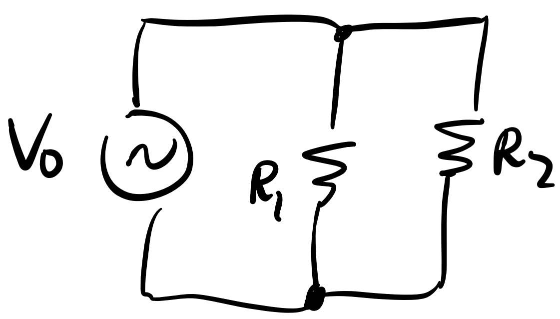
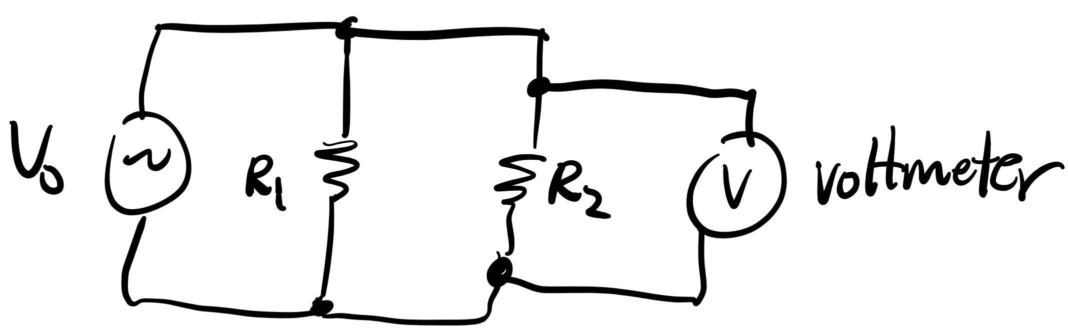
Voltage Measurements

Reminder: All components in parallel have same voltage diff. across them.

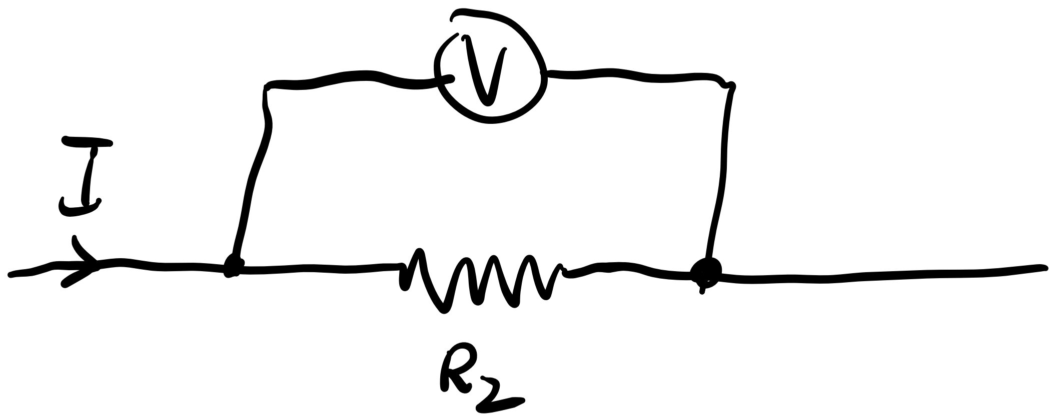


$V_0 = V_{R_1} = V_{R_2}$

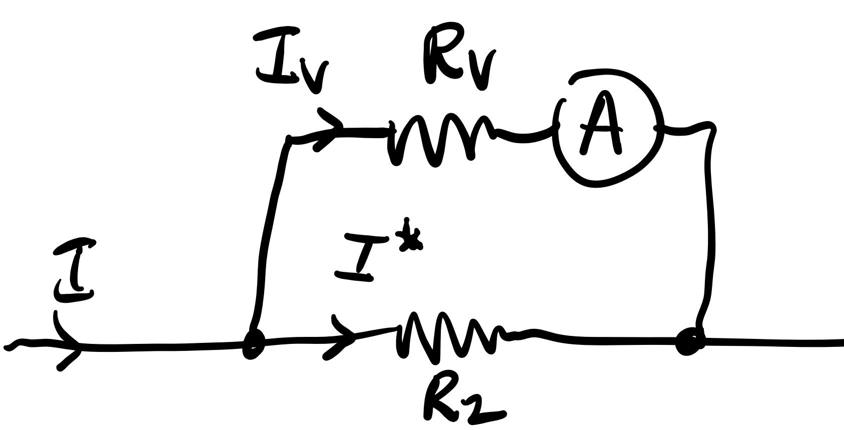
To make volt. meas, place meter in parallel w/ component of interest.



How do voltmeters work?



⇓



Inserting voltmeter changes the current in R_2 & therefore the voltage across R_2.

→ careful.

Make R_V very large s.t. I_V is small and $I^* \approx I$.

Ammeter meas. I_V. Then, since R_V is known, the volt. across R_2 is: $V_{R_2} \approx I_V R_V$.