CURRENT:

FLOW OF CHARGE ACROSS A SURFACE

UNIT: AMPERE $\longrightarrow$ 1 A = 1 COULOMB/S

FUNDAMENTAL CHARGE $e \sim 1.6e^{-19}$ C

SPROTT

$$I = \frac{dQ}{dt}$$

VOLTAGE: ELECTRICAL POTENTIAL DIFFERENCE

1 V = 1 JOULE/COULOMB

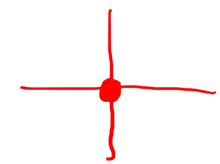
APPLY VOLTAGE DIFFERENCE BETWEEN 2 POINTS:
CURRENT WILL FLOW

$I = V/R \longrightarrow$ RESISTANCE; DETERMINED BY GEOMETRY, MATERIALS, TEMPERATURE [PHONON, IMPURITY SCATTERING]

OHM'S LAW

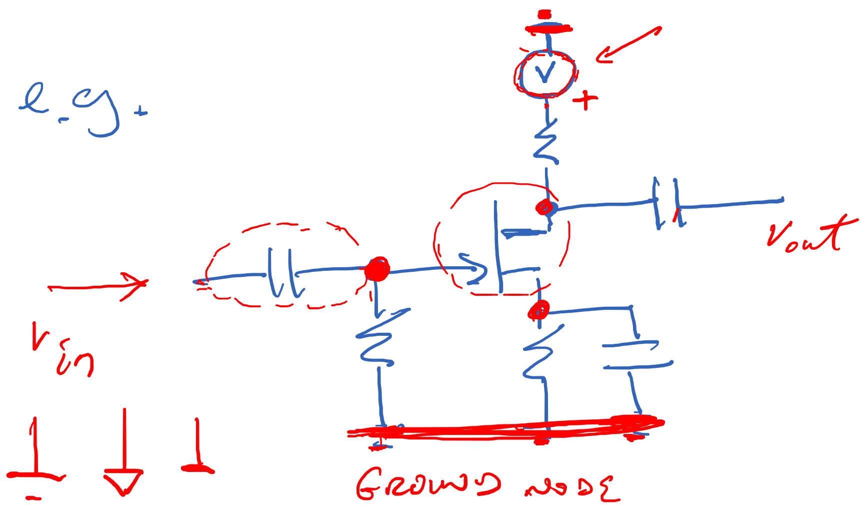
CONDUCTANCE $G = 1/R$

ELECTRICAL CIRCUIT: NETWORK OF NODES JOINED BY BRANCHES



VOLTAGES @ NODES,
CURRENTS THRU BRANCHES

e.g.

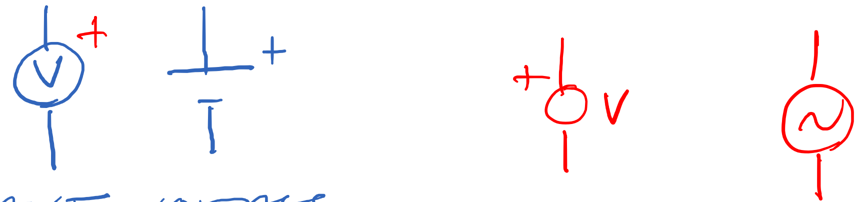


CIRCUIT INCLUDING
SOURCE,
IMPEDANCES,
3-TERMINAL ACTIVE ELEMENT
(n-CHANNEL JFET)

CURRENT FLOW ACROSS A POTENTIAL DROP DISSIPATES POWER
[ASSUMING I & V ARE IN PHASE: MORE ON THIS LATER]

$$P = IV = I^2R = V^2/R$$

VOLTAGE SOURCE



IDEAL: SUPPLIES A CONSTANT VOLTAGE, REGARDLESS OF CURRENT THRU IT

[i.e., IDEAL V. SOURCE HAS ZERO INTERNAL RESISTANCE]

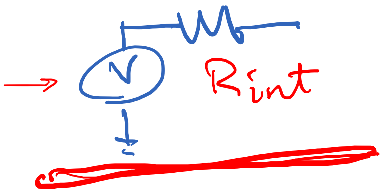
CURRENT SOURCE

IDEAL: SUPPLIES CONSTANT CURRENT, REGARDLESS OF VOLTAGE ACROSS IT

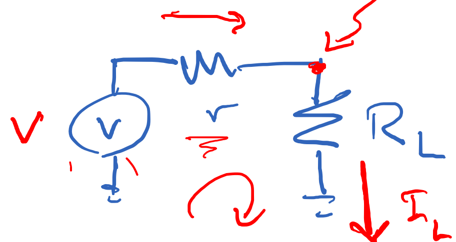
[i.e., IDEAL I SOURCE HAS INFINITE INTERNAL RESISTANCE]

PRACTICAL SOURCES

V. SOURCE CAN BE MODELED AS IDEAL SOURCE IN SERIES W/ INTERNAL RESISTANCE



CONNECT TO LOAD R_L:



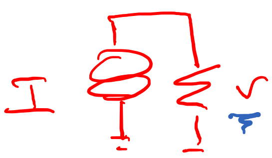
$$V_L = I_L \cdot R_L$$

$$I_L = \frac{V}{r + R_L}$$

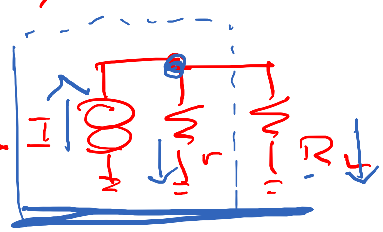
$$V_L = \frac{R_L}{r + R_L} V \approx V$$

PROVIDED $R_L >> r$

I. SOURCE CAN BE MODELED AS IDEAL SOURCE IN PARALLEL W/ INTERNAL RESISTANCE



CONNECT TO LOAD



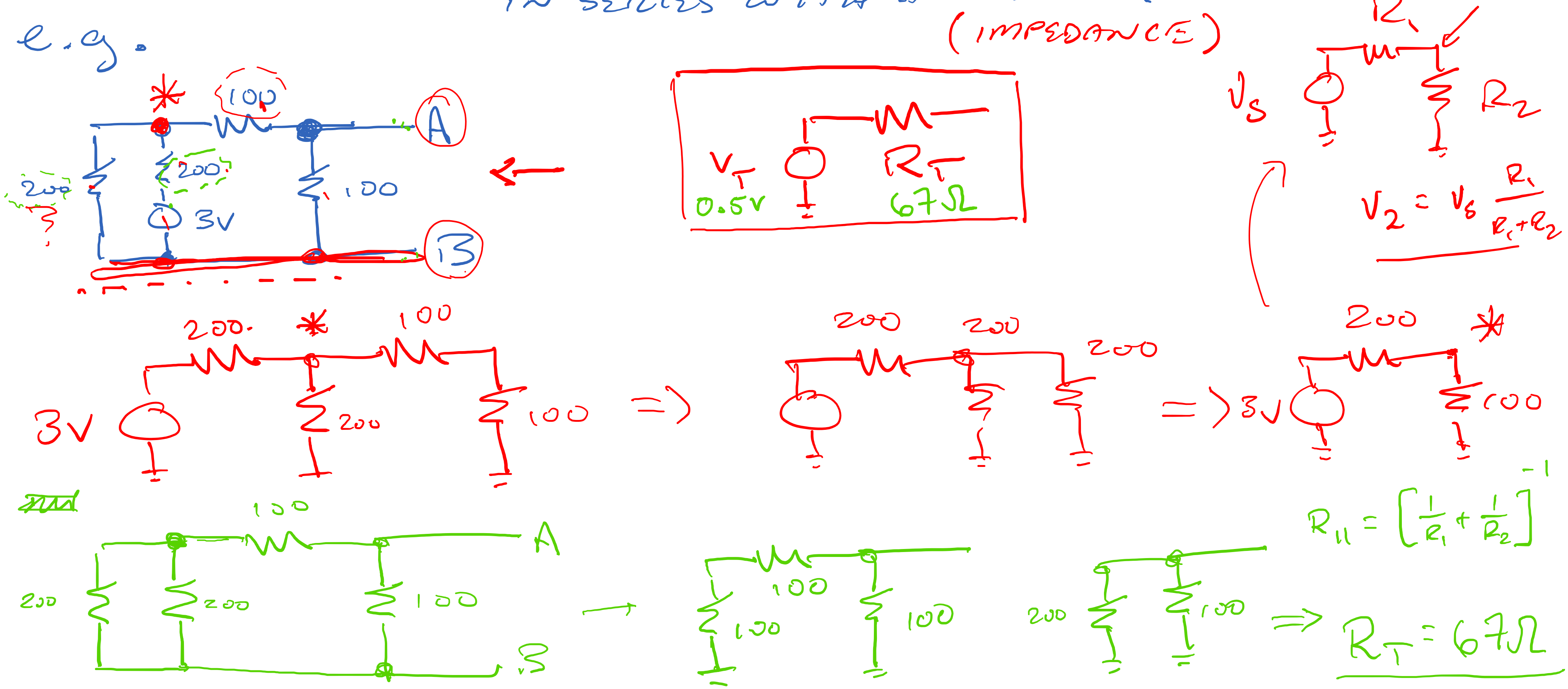
$$I_L = I \frac{1/R_L}{1/R_L + 1/r} = I \frac{r}{r + R_L}$$

$I_L \approx I$, PROVIDED $r >> R_L$

THEVENIN TH'M:

ANY LINEAR, 2-TERMINAL NETWORK CAN BE EXPRESSED AS A VOLTAGE SOURCE IN SERIES WITH A RESISTOR (IMPEDANCE)

e.g.

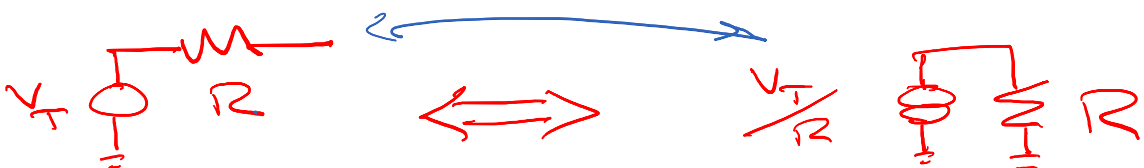


NORTON TH'M:

ANY LINEAR, 2-TERMINAL NETWORK CAN BE EXPRESSED AS IDEAL CURRENT SOURCE IN PARALLEL WITH A RESISTOR [IMPEDANCE]

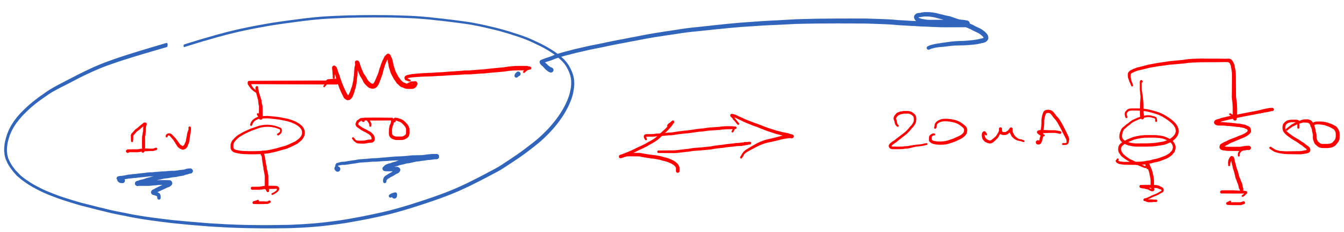
TO DETERMINE THEVENIN/NORTON EQUIVALENT, MEASURE V_{oc} [OPEN CIRCUIT] & I_{sc} [SHORT CIRCUIT]

THEVENIN-NORTON TRANSFORMATION:

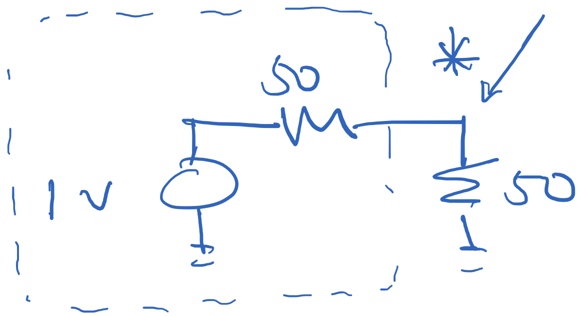


$$I_N = \frac{V_T}{R_T} = \frac{1V}{50\Omega} = 20mA$$

e.g.

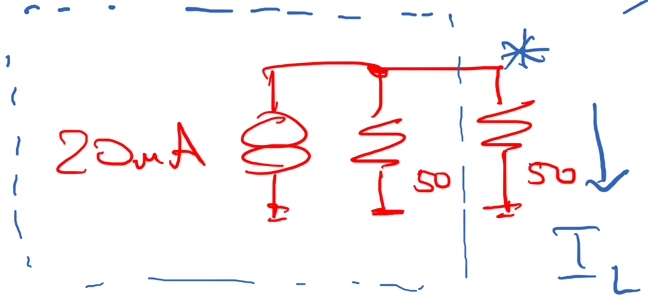


CONSIDER 50 Ω LOAD:



$V_* = 0.5V$

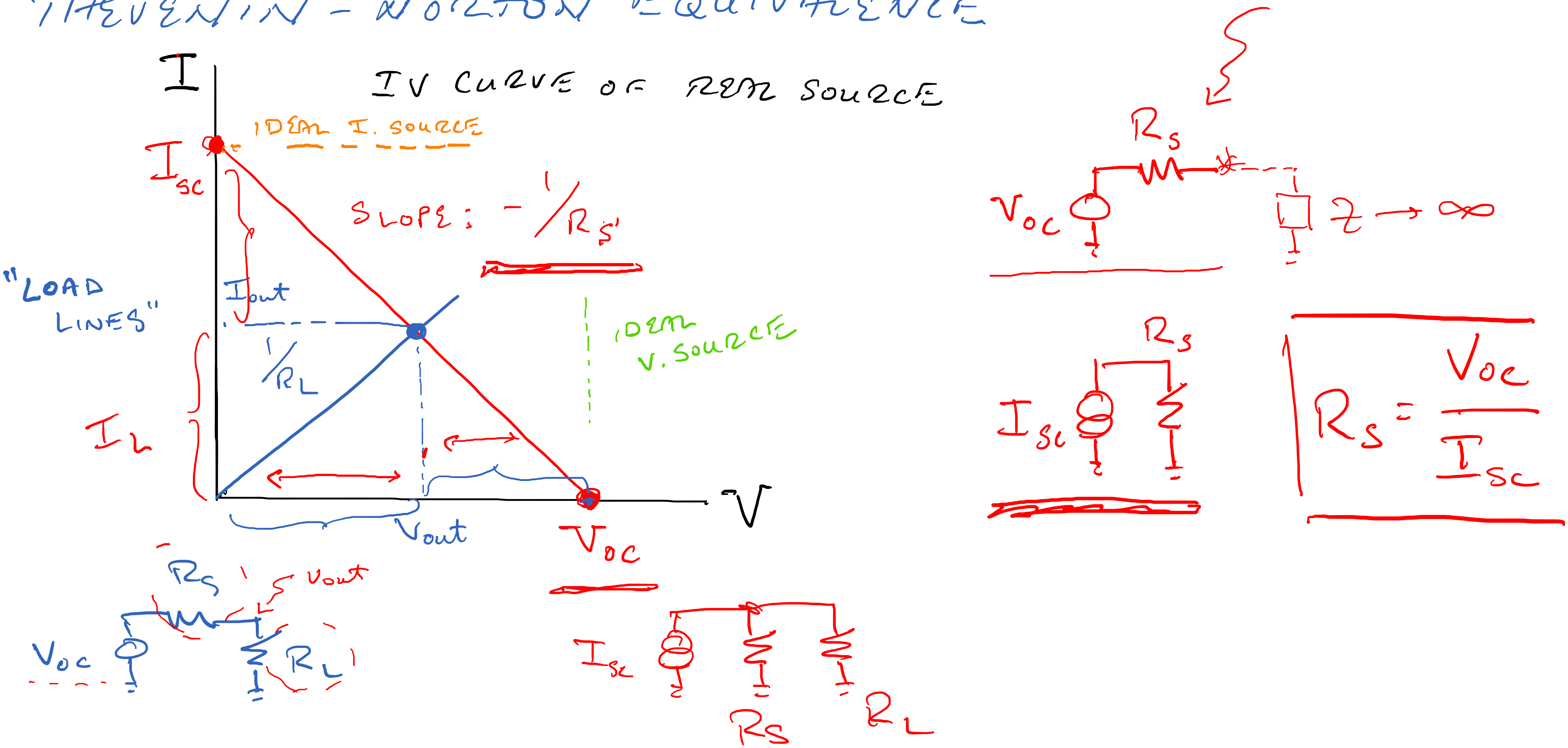
OR



$V_* = I_L \cdot 50\Omega$

$= 10mA \cdot 50\Omega = 0.5V$

THEVENIN - NORTON EQUIVALENCE

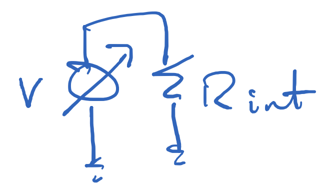


METERS

VOLTMETER : CONNECT ACROSS 2 NODES

IDEAL: INFINITE INTERNAL IMPEDANCE

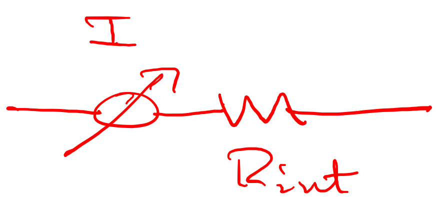
PRACTICAL V.METER MODELED AS IDEAL METER IN PARALLEL W/ FINITE INTERNAL IMPEDANCE



AMMETER : INSERT INTO A BRANCH

IDEAL: ZERO INTERNAL RESISTANCE

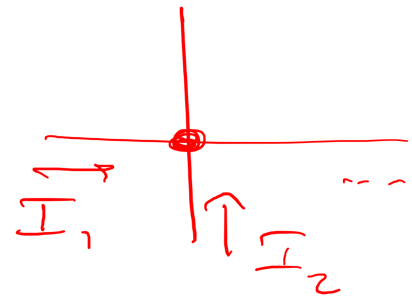
PRACTICAL AMMETER MODELED AS IDEAL METER IN SERIES W/ NONZERO INTERNAL RESISTANCE



CIRCUIT THEOREMS

KIRCHOFF'S LAWS

- SUM OF CURRENTS FLOWING INTO A NODE IS ZERO
  [CONSERVATION OF CHARGE]



→ - SUM OF VOLTAGE DROPS AROUND A CLOSED LOOP IS ZERO
  [CONSERVATION OF ENERGY]

CIRCUIT TH'MS, CONT'D

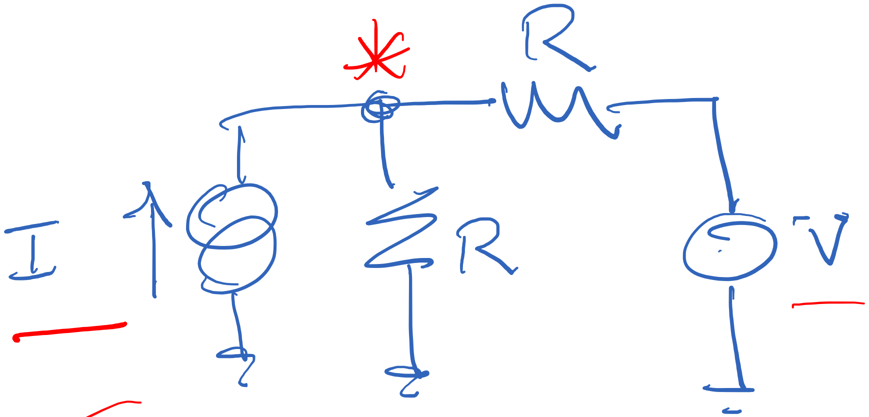
SUPERPOSITION TH'M

IN A CIRCUIT w/ MULTIPLE SOURCES, CURRENT IN A BRANCH [VOLTAGE @ A NODE] IS THE SUM OF CURRENTS [VOLTAGES] PRODUCED BY EACH SOURCE SEPARATELY, WITH OTHER SOURCES REPLACED BY THEIR INTERNAL RESISTANCES

HOLDS FOR **LINEAR** CIRCUITS

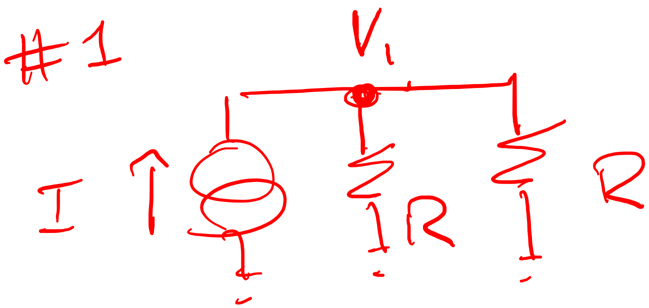
ALLOWS US TO CALCULATE RESPONSE OF A CIRCUIT TO ARBITRARY DRIVE WAVEFORM USING FOURIER DECOMPOSITION & CONCEPT OF FREQUENCY-DEPENDENT IMPEDANCE

EXAMPLE



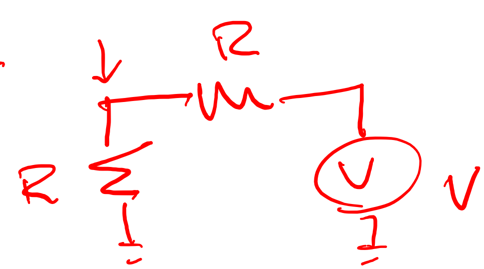
$$V_* = \frac{1}{2} I R + \frac{V}{2}$$

#1



$$V_1 = I \cdot \frac{R}{2}$$

#2



$$V_2 = \frac{V}{2}$$