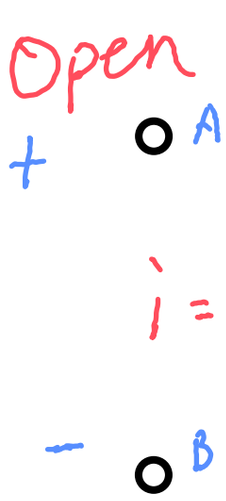
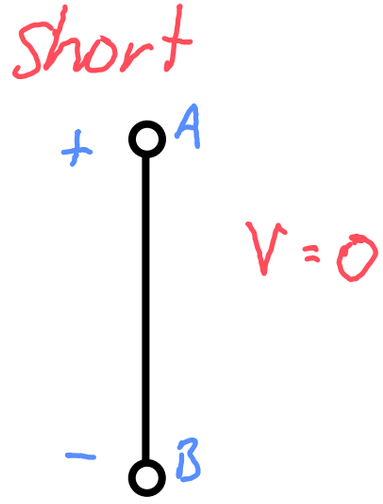
Last Class…

What is characteristic of an open and a closed loop circuit?



$V = V_A - V_B$



$A = B$

i is not 0

THE OHIO STATE UNIVERSITY

COLLEGE OF ENGINEERING

Capacitors and Inductors

This Lecture…

- Learning Objectives:
  - Define the i-v relationship for capacitors and inductors.
  - Determine voltage and current across capacitors and inductors under DC and steady state conditions

Capacitors

- Stores energy in electric field between two conducting plates.
- For DC, capacitor looks like open circuit.

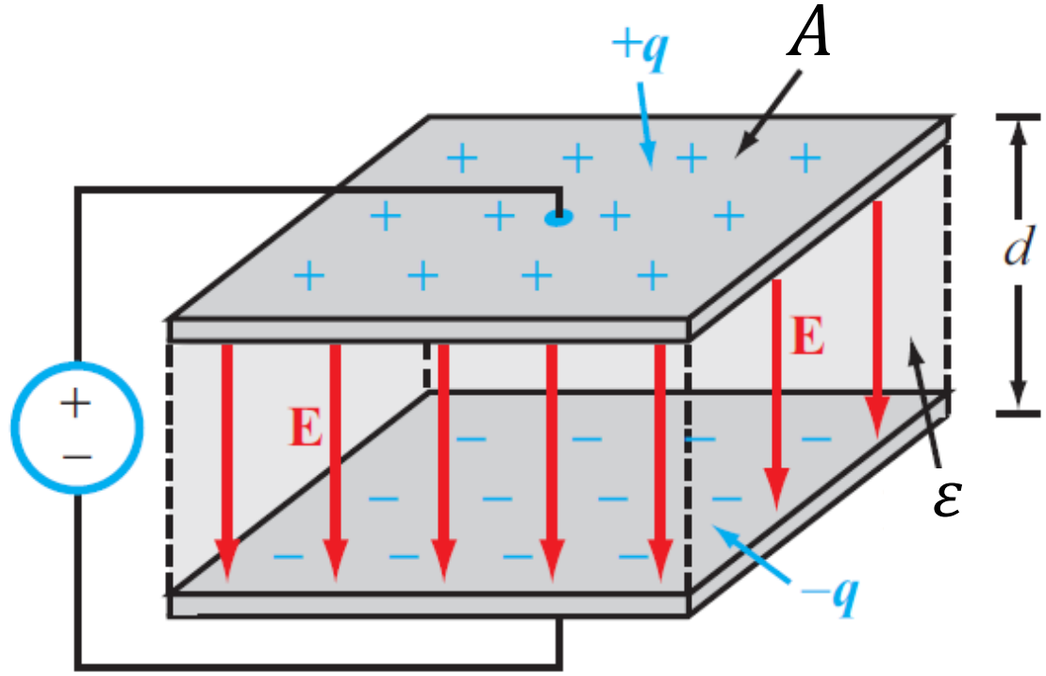
i-v characteristic

C = capacitance = Farads [F]

$V = IR$

$$i_c(t) = C \cdot \frac{dV_c(t)}{dt}$$

$$V_c(t) = \frac{1}{C}\int i_c(t)\,dt$$



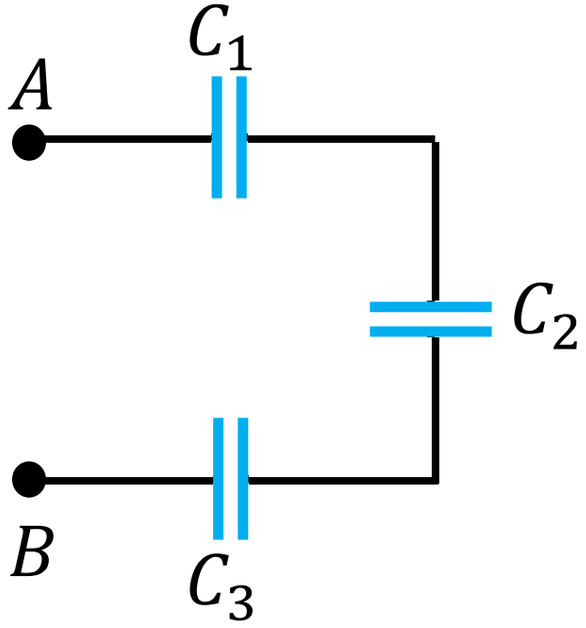
$C = 10\ \mu F$

Capacitors

Calculating equivalent capacitance:

- Capacitors in series combine like resistors in parallel.
- Capacitors in parallel combine like resistors in series.

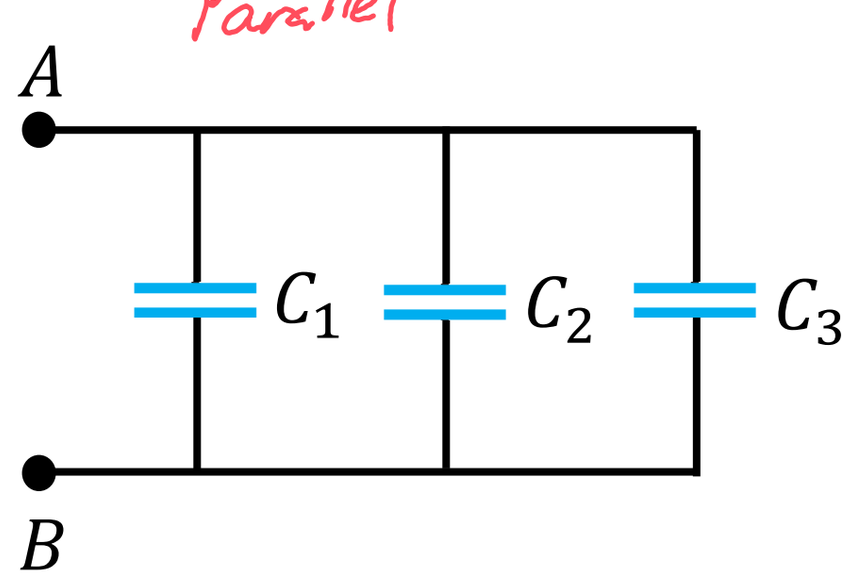
Series



Same Current

$$C_{eq} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

Parallel



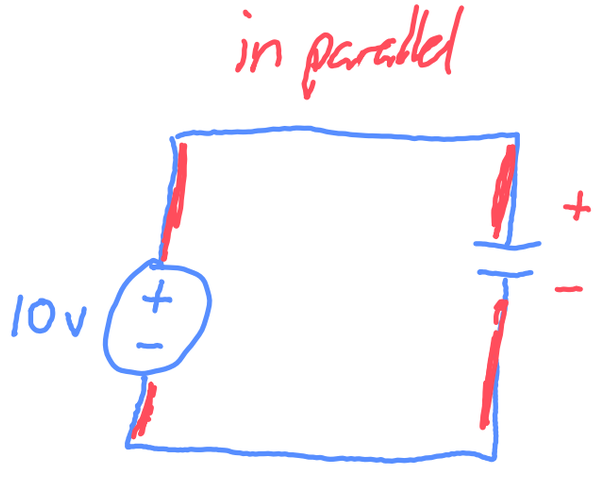
Same voltage

$$C_{eq} = C_1 + C_2 + C_3$$

Capacitor

$$i_C(t) = C\frac{dv_C(t)}{dt}$$

$$v_C(t) = \frac{1}{C}\int_0^t i_C(\tau)d\tau + v_0$$

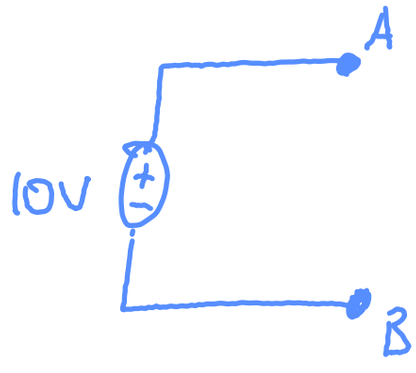


$V_C = 10V$

$i_C = C \cdot \frac{d10^0}{dt} = 0$

can be modeled as an open circuit (only on DC)

In a DC system and steady state:



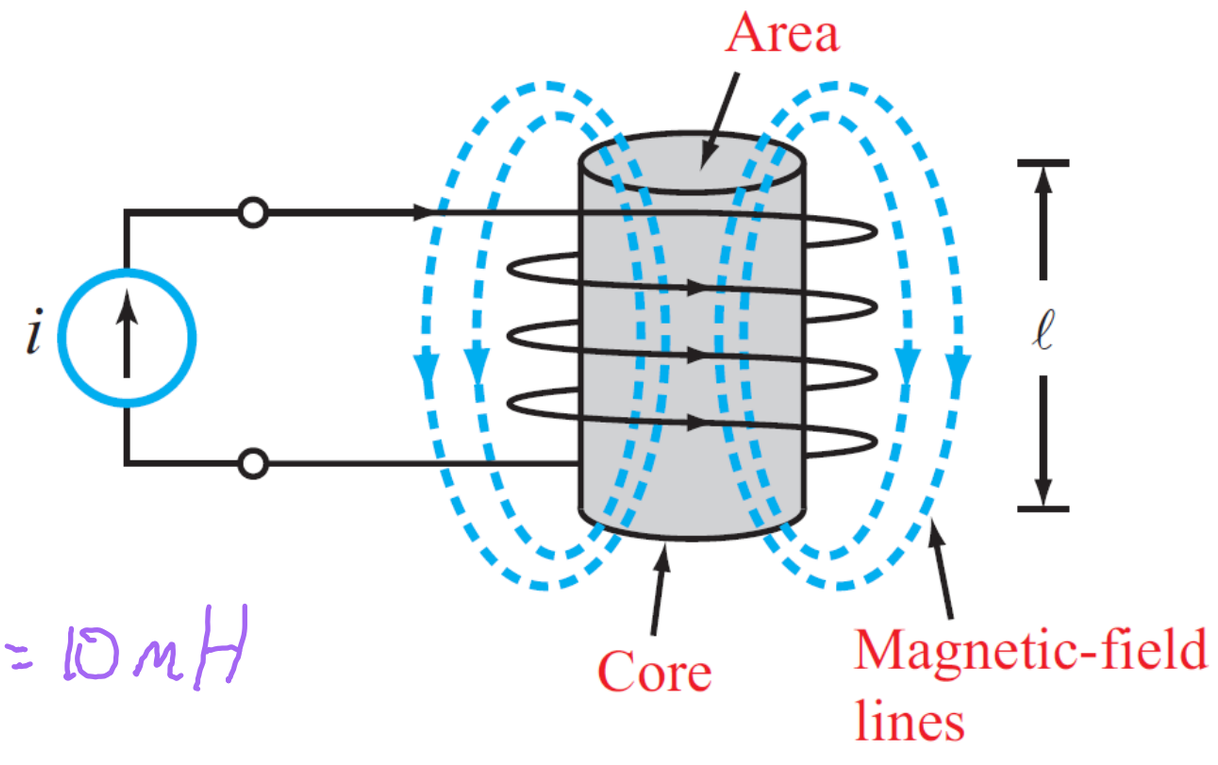
Inductors

- Stores energy in magnetic field of a conducting coil.
- Inductor in a DC circuit equivalent to a short circuit

i-v characteristic

$$v_L(t) = L \cdot \frac{di_L(t)}{dt}$$

L = inductance = Henrys [H]

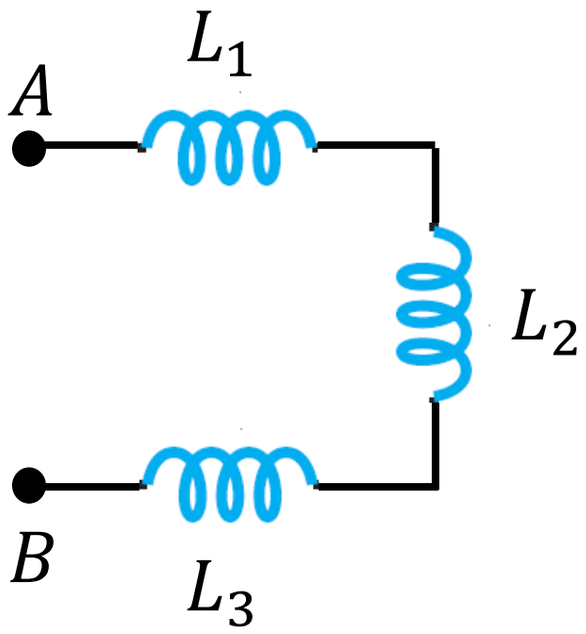


L = 10 mH

Inductors

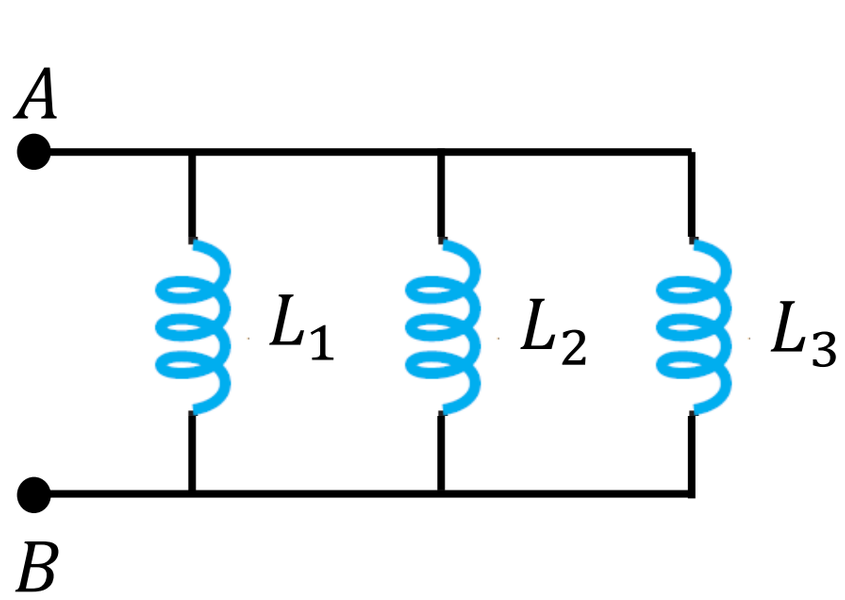
Calculating equivalent inductance

- Inductors in series combine like resistors in series.
- Inductors in parallel combine like resistors in parallel.



Same current

$L_{eq} = L_1 + L_2 + L_3$



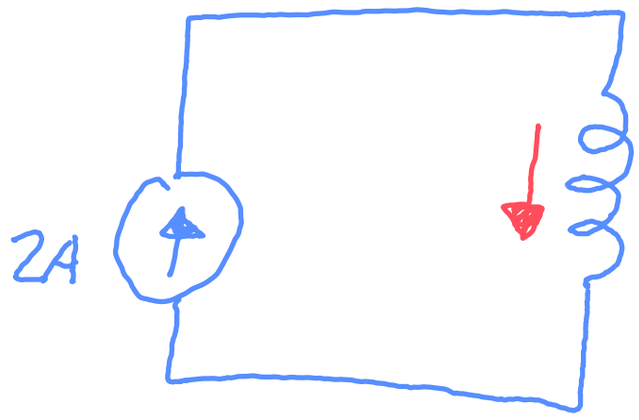
Same voltage

$$L_{eq} = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}}$$

Inductor

$$v_L(t) = L\frac{di_L(t)}{dt}$$

$$i_L(t) = \frac{1}{L}\int_0^t v_L(\tau)d\tau + i_0$$

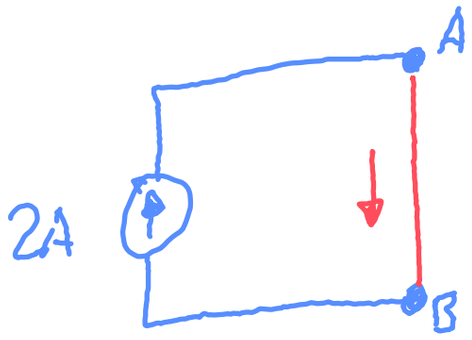


$i_L = 2A$ in series

$V_L = L\frac{d20}{dt} = 0V$

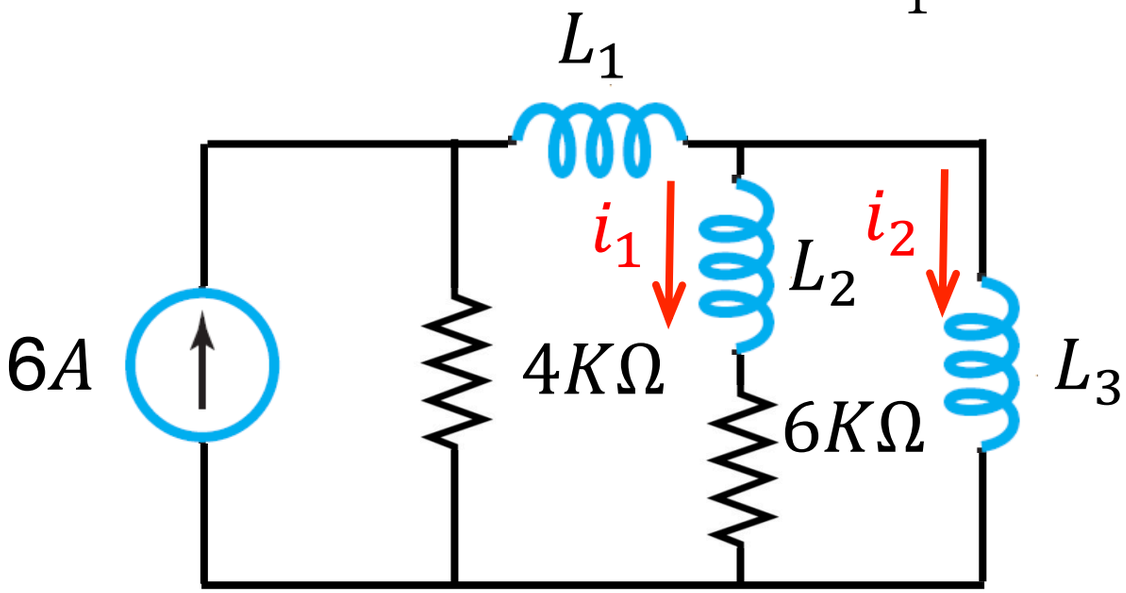
Can be modeled as short circuit

In a DC system and steady state:

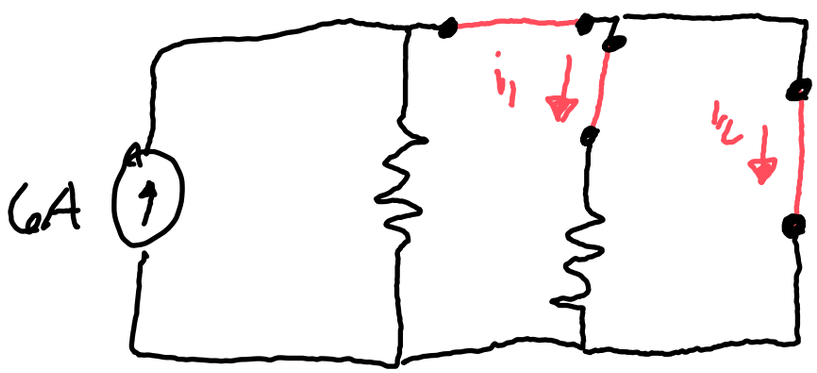


Example 1

Determine the current i_1 and i_2 in the circuit under DC condition.



DC → inductors = short circuit



Shorted out

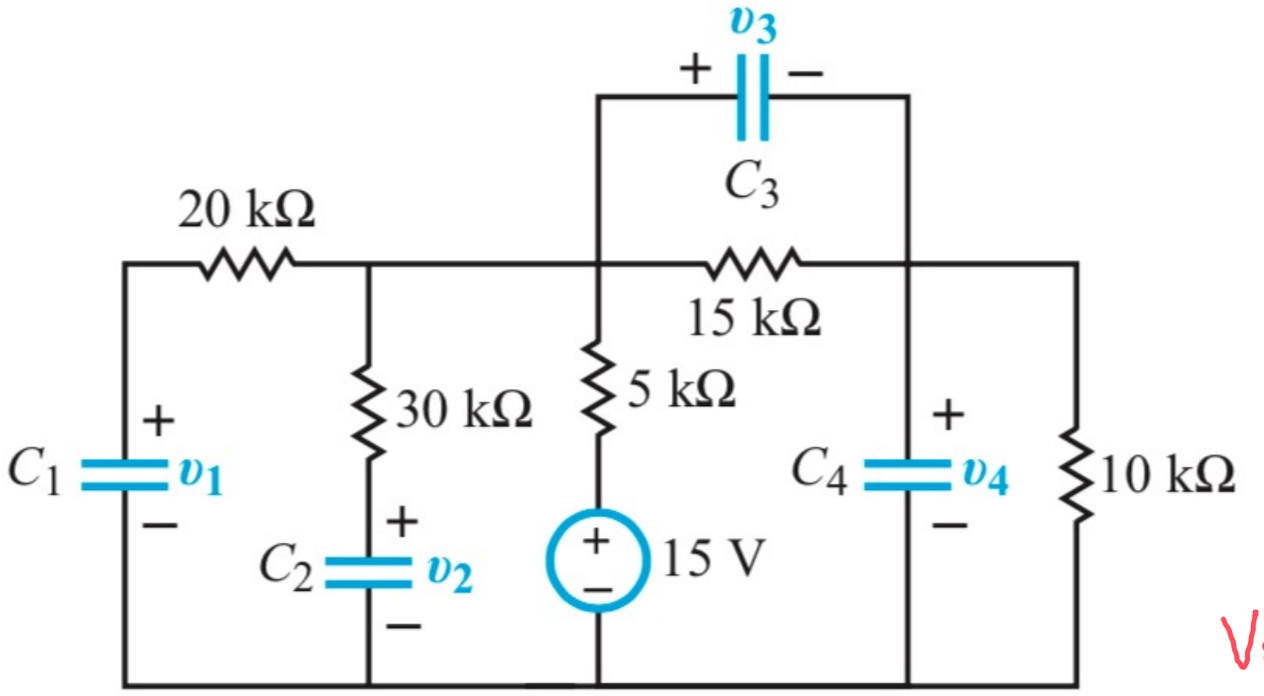
V=0 → i=0

$i_1 = 0\,A$

$i_2 = 6\,A$

Example 2

Determine voltage υ1 to υ4 in the circuit under dc conditions.



$V_1 = V_2 = V_A$ $\quad V_C = 0V$

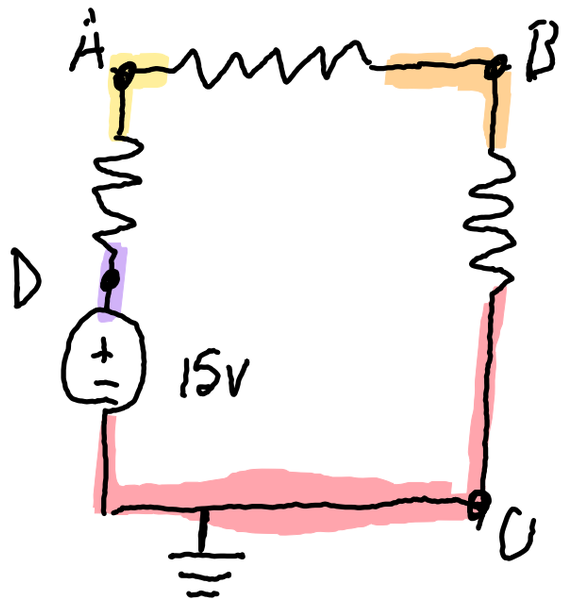
$V_3 = V_A - V_{13}$ $\quad V_D = 15V$

$V_4 = V_B$

Voltage Division

$V_{10} = \frac{10k}{30k} \cdot 15 = 5V$

$V_B = 5V$



$V_5 = \frac{5k}{30k} \cdot 15 = 2.5V$

$V_5 = V_D - V_A = 15 - 2.5 = 12.5V$

$V_A = 12.5V$