ITP272 SENSOR TECHNOLOGIES AND PROJECT

L03: Basic Electronics

AGENDA

- Basic Electronics
  - Voltage, Current and Resistance
  - Resistor and Capacitor
  - Diode and Light Emitting Diode

VOLTAGE, CURRENT, RESISTANCE AND POWER

Voltage

- A difference in charge between two objects
- It is also often mention as electric potential difference between two points
- Sometimes referred to as electromotive force (E.M.F)

SI Unit

- Volts (V)

Symbol

- V

VOLTAGE, CURRENT, RESISTANCE AND POWER

Current

- A flow of electric charge between two points with electric potential difference and linked
- Electrons will flow from the negatively charged body to the positively charged body

SI Unit

- Ampere (A)

Symbol

- I

BATTERY	Li-Ion 3000 mAh battery

- Can supplied 3000mA continuously for 1 hour
- Depends on phone usage, you consume different amount of mA every second, thus determine when you battery runs dry

VOLTAGE, CURRENT, RESISTANCE AND POWER

Resistance

D

- An opposition to the flow of electrical charge between two point
- Acts like amount of friction to resist movement of electrons

SI Unit

- Ohm (Ω)

Symbol

- R

VOLTAGE, CURRENT, RESISTANCE AND POWER

Resistance

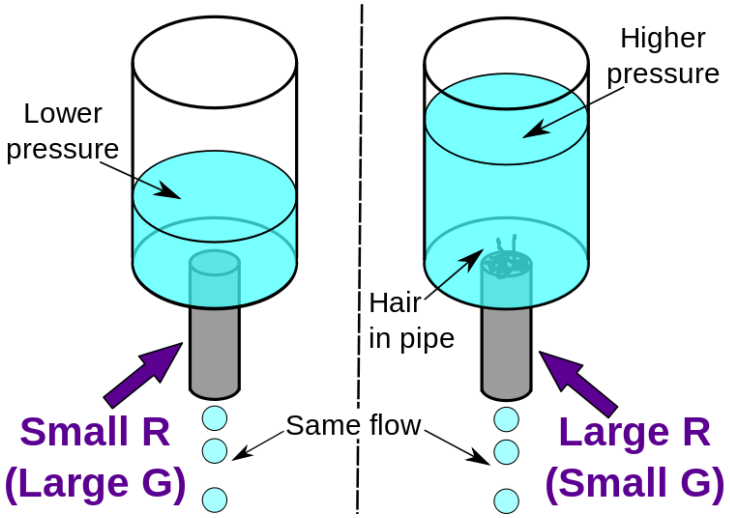
Factors that determines resistance of a material

- Type of material
  - The resistance of various types of materials are different
- Length
  - The resistance of a material is directly proportional to its length. The longer the material is, the more resistance it has. This is because the electrons must flow through more material, and therefore meets more friction over the entire distance.
- Cross Sectional Area
  - The resistance of a material is inversely proportional to the cross sectional area of the material. This means that the thicker the substance is across, the lower the resistance. This is because the larger the cross sectional area is, the less friction there is over a given length

VOLTAGE, CURRENT, RESISTANCE AND POWER

Electrical Relationship Analogy

- Voltage ⇔ Water Pressure
- Current ⇔ Flow of water (fast / slow)
- Resistance ⇔ Clogged Hair inside pipe



http://en.wikipedia.org/wiki/Electrical_resistance_and_conductance

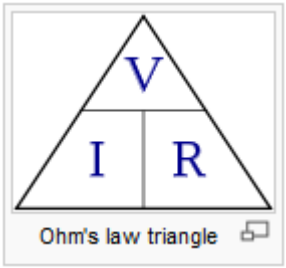
VOLTAGE, CURRENT, RESISTANCE AND POWER

Ohms's Law

D

- It states that the current through a conductor between two points is directly proportional to the potential difference across the two points.
- This give rise to the following formula

$$I = \frac{V}{R} \quad \text{or} \quad V = IR \quad \text{or} \quad R = \frac{V}{I}.$$



I : Current

V: Voltage

R : Resistance

VOLTAGE, CURRENT, RESISTANCE AND POWER

Example

In a electronic circuit, if the voltage across the components is 5 volts and the resistance of the circuit is 1k ohms, what is the current that is flowing through the circuit?

- V = 5 V
- R = 1k or 1000 Ω
- Using

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

- Current, I = 5 / 1000 = 0.005 A or 5 mA (milli Ampere)

RESISTOR AND CAPACITOR

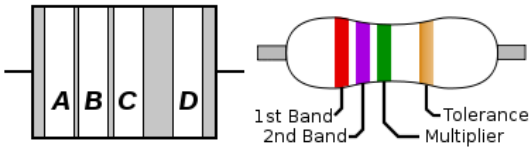
Conductors, Insulators and resistors

- Conductors
  - Objects which have very low resistance to flow of electric current
  - A wire is an example of an electrical conductor
- Insulator
  - Objects which have extremely high resistance to electric current flow

- Resistor 
  - A two-terminal electrical component created with definite resistance values.
  - It is used to control the amount of electrical current flowing through the electronic circuits

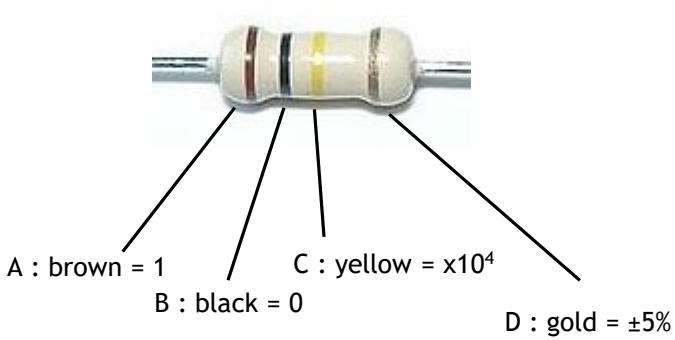
RESISTOR AND CAPACITOR

Resistor Colour code



band **A** : first significant figure of component value (left side)
band **B** : the second significant figure
(Some precision resistors have a third significant figure)
band **C** : the decimal multiplier
band **D** : if present, indicates tolerance of value in percent
(no band means 20%)

Color	Significant figures	Multiplier	Tolerance	
Black	0	$\times 10^0$	–	
Brown	1	$\times 10^1$	±1%	F
Red	2	$\times 10^2$	±2%	G
Orange	3	$\times 10^3$	–	
Yellow	4	$\times 10^4$	(±5%)	–
Green	5	$\times 10^5$	±0.5%	D
Blue	6	$\times 10^6$	±0.25%	C
Violet	7	$\times 10^7$	±0.1%	B
Gray	8	$\times 10^8$	±0.05% (±10%)	A
White	9	$\times 10^9$	–	
Gold	–	$\times 10^{-1}$	±5%	J
Silver	–	$\times 10^{-2}$	±10%	K
None	–	–	±20%	M



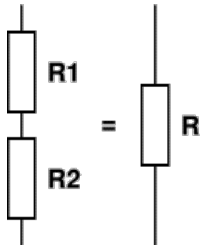
Resistor value = ABC =10 x 10^4 = 100 k Ω , D indicates that the accuracy is ± 5%

RESISTOR AND CAPACITOR

Resistor

Connected in Series

- Total Resistance becomes bigger and is equal to the individual resistances added together
- Combined resistance, R = R1 + R2



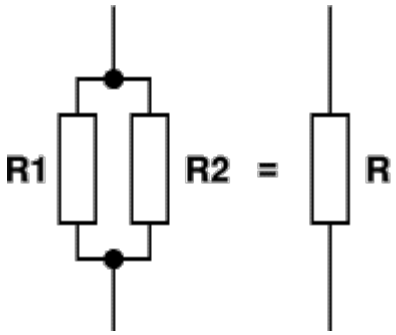
RESISTOR AND CAPACITOR

Resistor

Connected in Parallel

- Total Resistance is less than any of the individual resistances
- Combined resistance, R, is found using the following formula

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2}$$



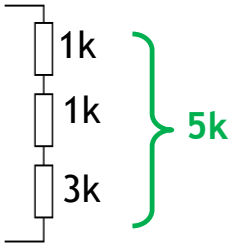
RESISTOR AND CAPACITOR

Resistor

Example

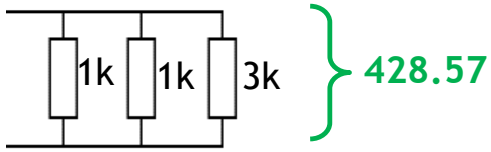
There are 3 resistors, R1 = 1k Ω, R2 = 1k Ω, R3 = 3k Ω.

- Find the combined resistance when 3 of them are connected in series
  - Combined resistance, R = 1k + 1k +3k = 5k Ω



- Find the combined resistance when 3 of them are connected in parallel
  - Combined resistance, R = 428.57 Ω

$$\Leftrightarrow \frac{1}{R} = \frac{1}{1\,k} + \frac{1}{1\,k} + \frac{1}{3\,k}$$

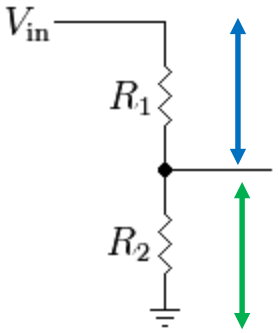


RESISTOR AND CAPACITOR

Resistor

Voltage Divider

- The voltage across each resistor is distributed proportional to the resistance across



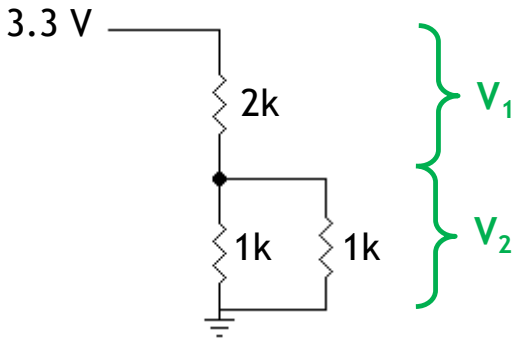
$$V_{R1} = \frac{R1}{R1+R2} \times V_{in}$$

$$V_{R2} = \frac{R2}{R1+R2} \times V_{in}$$

RESISTOR AND CAPACITOR

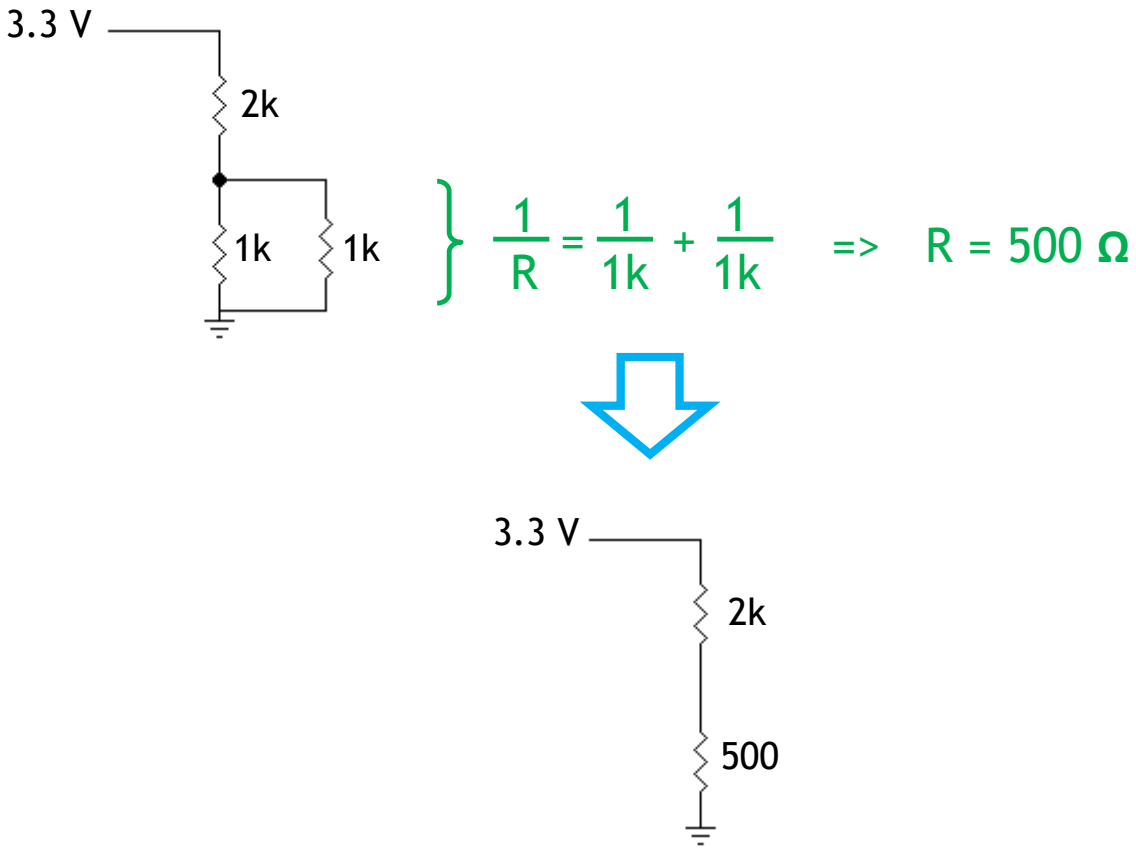
Resistor

With the following circuit, use voltage divider to find out voltage of V_1 and V_2?



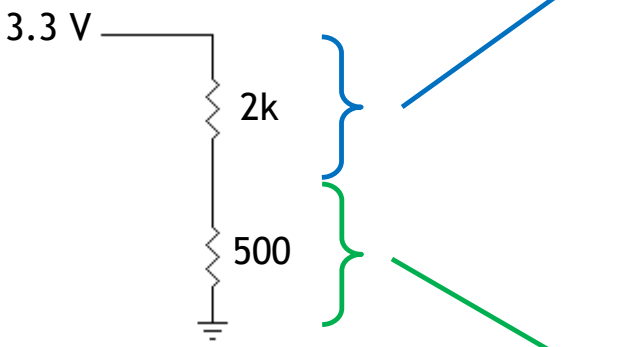
RESISTOR AND CAPACITOR

Combined required resistance to form the distribution across the voltage



RESISTOR AND CAPACITOR

Use Voltage Divider rule to find out the different voltages

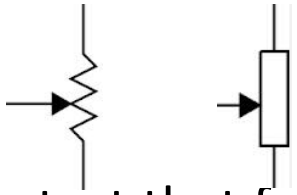


$$V_1 = \frac{2k}{2k + 500} \times 3.3 = 2.64\ V$$

$$V_2 = \frac{500}{2k+500} \times 3.3V = 0.66\ V$$

RESISTOR AND CAPACITOR

Potentiometer (Rotary Angle)



- A three-terminal resistor with a sliding contact that forms an adjustable voltage divider
- Sometimes referred to as a pot
- Allows variable resistance distribution to varies the voltage distribution
- Commonly used to control electrical devices such as volume controls on audio equipment

RESISTOR AND CAPACITOR

Capacitor

D

- A two-terminal electrical component used to store energy in an electric field.
- Widely used in electronic circuits for
  - Block direct current while allowing alternating current to pass
  - Smooth the output of power supplies
  - Tune radios to particular frequencies
  - Stabilize voltage and power flow

SI Unit

- farad (F)

Symbol

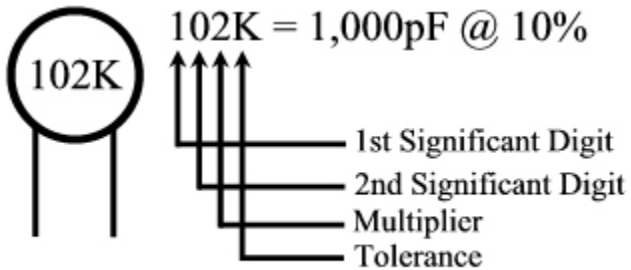
- C

RESISTOR AND CAPACITOR

Capacitor number code

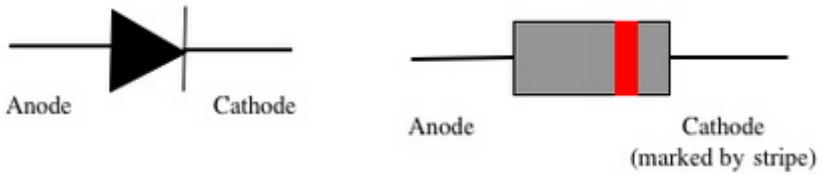
- 1st number is the 1st digit,
- 2nd number is the 2nd digit,
- 3rd number (Multiplier) is the number of zeros to give the capacitance in pF.
- Letter (if any) is the Tolerance

Letter	Tolerance
D	0.5 pF
F	1 %
G	2 %
H	3 %
J	5 %
K	10 %
M	20 %
P	+100, -0 %
Z	+80, -20 %



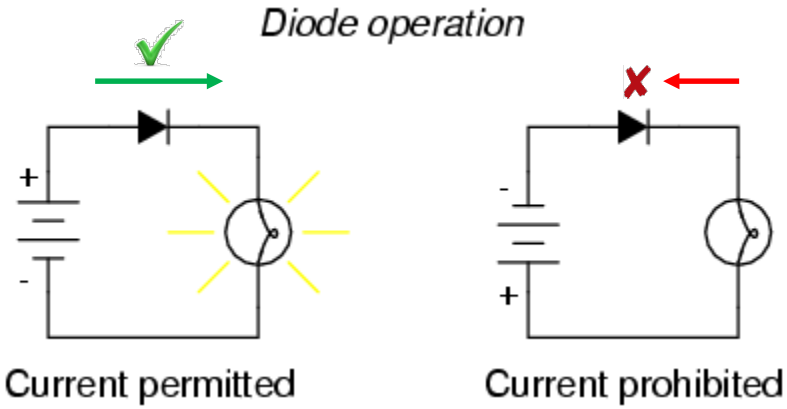
DIODE AND LIGHT EMITTING DIODE (LED)

Diode



D

- It is a two-terminal electronic component with low (ideally zero) resistance to current flow in one direction, and high (ideally infinite) resistance in the other.
- It is often used as a form of protection to prevent current from flowing in reverse direction



DIODE AND LIGHT EMITTING DIODE (LED)

Light Emitting Diode

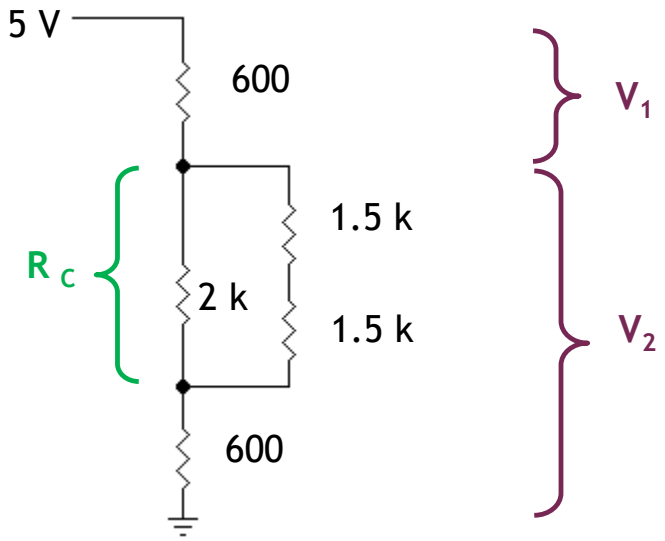
D

- It is special diode that will emit light when current flows through it
- Apart from having same function is a diode, it is often used as a light source indicator
- The brightness of the light depends on the current flowing through
- A resistor is usually used to control current flowing through the LED to adjust the brightness

REVIEW QUESTIONS

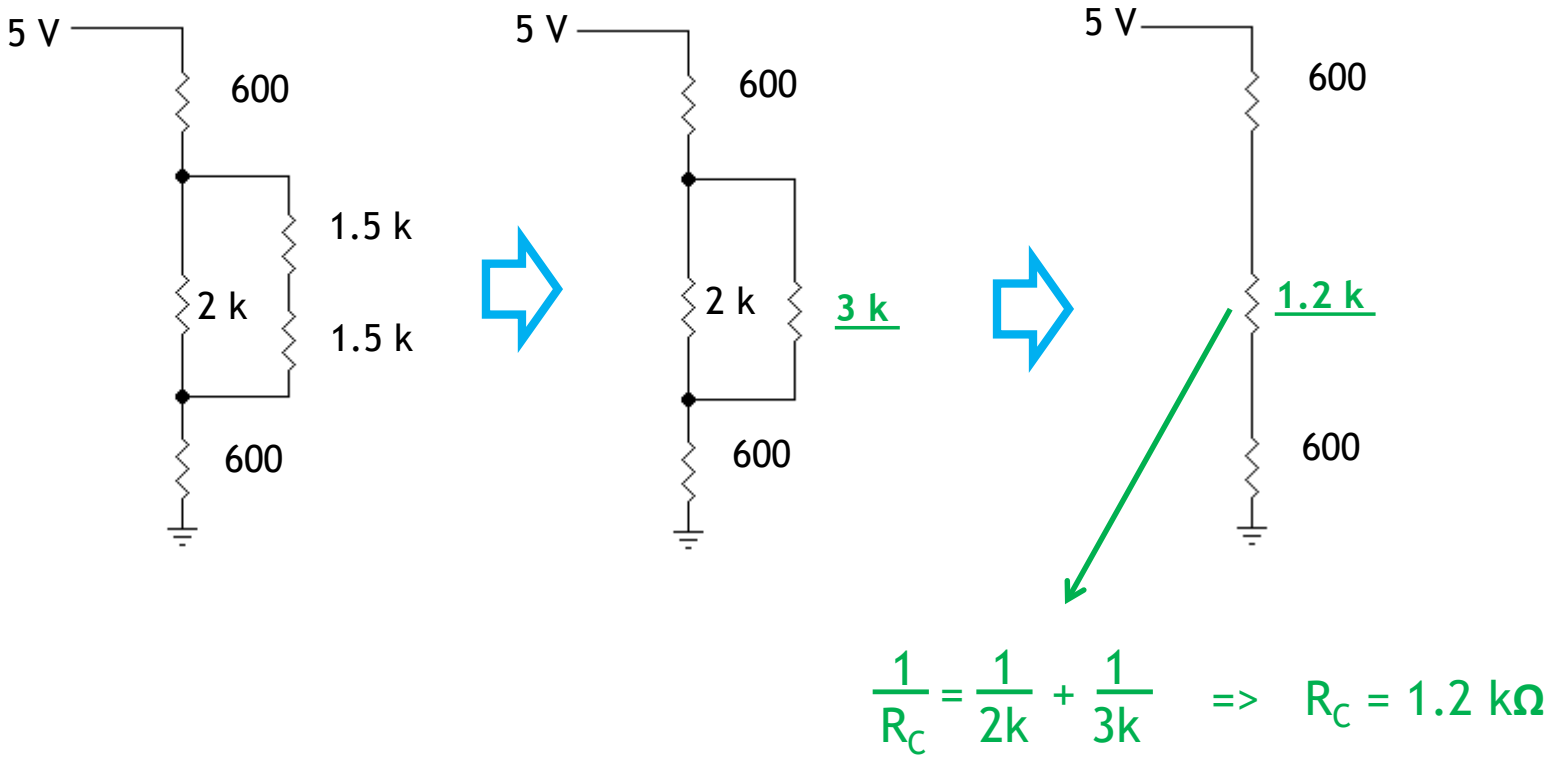
REVIEW QUESTION

Find the combined resistance R_C and use voltage divider to compute V_1 and V_2.



ANSWER

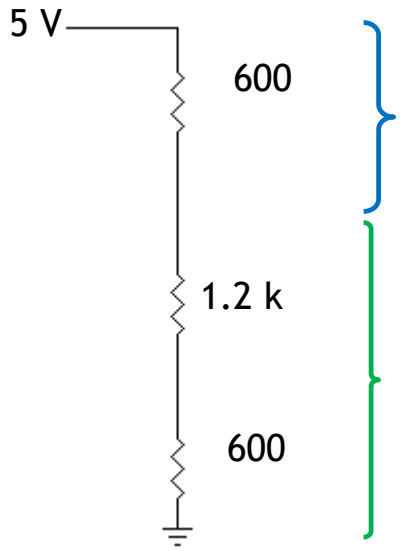
Combined required resistance to form the distribution across the voltage



$$\frac{1}{R_C} = \frac{1}{2k} + \frac{1}{3k} \quad \Rightarrow \quad R_C = 1.2\ k\Omega$$

ANSWER

Use Voltage Divider rule to find out the different voltages

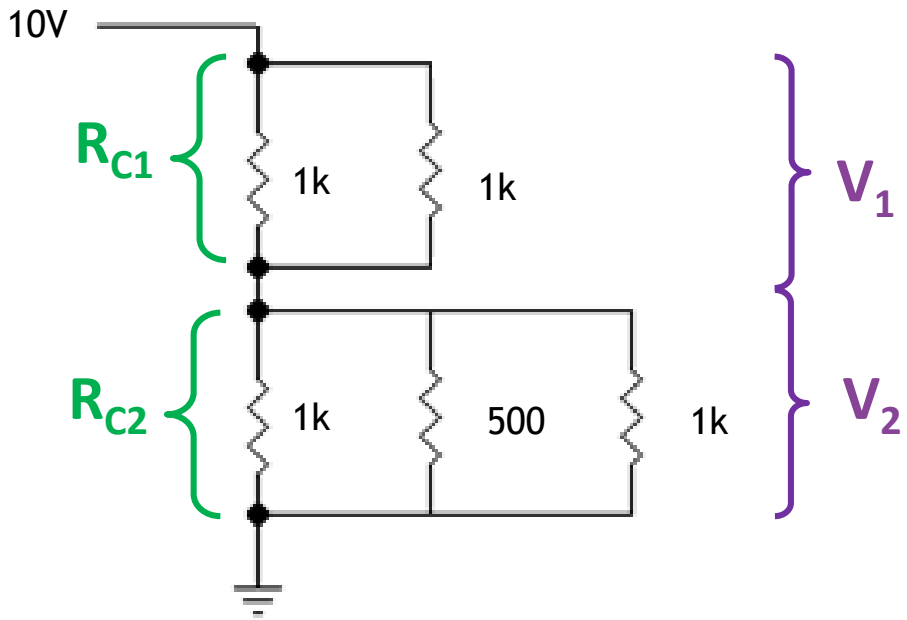


$$V_1 = \frac{600}{600 + (1.2k + 600)} \times 5\ V = 1.25\ V$$

$$V_2 = \frac{(1.2k + 600)}{600 + (1.2k + 600)} \times 5\ V = 3.75\ V$$

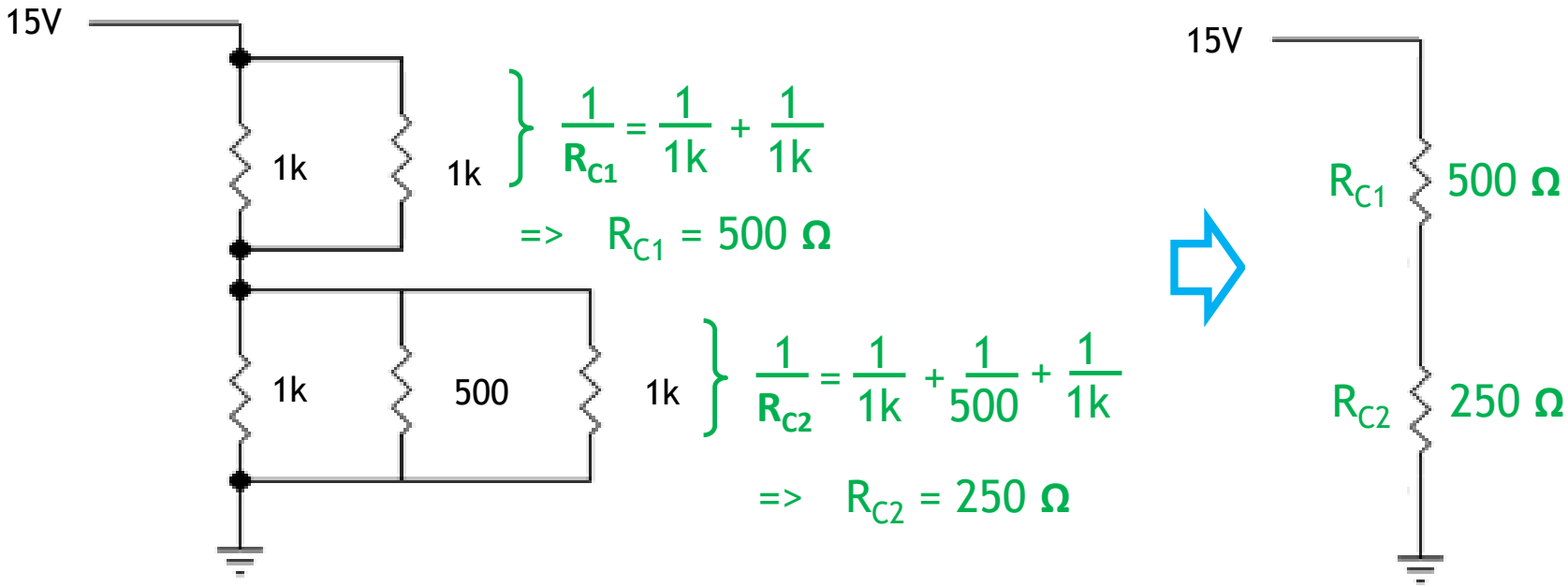
REVIEW QUESTION

Find the combined resistances $R_{C1,}$ R_{C2} and use voltage divider to compute V_1 and V_2.



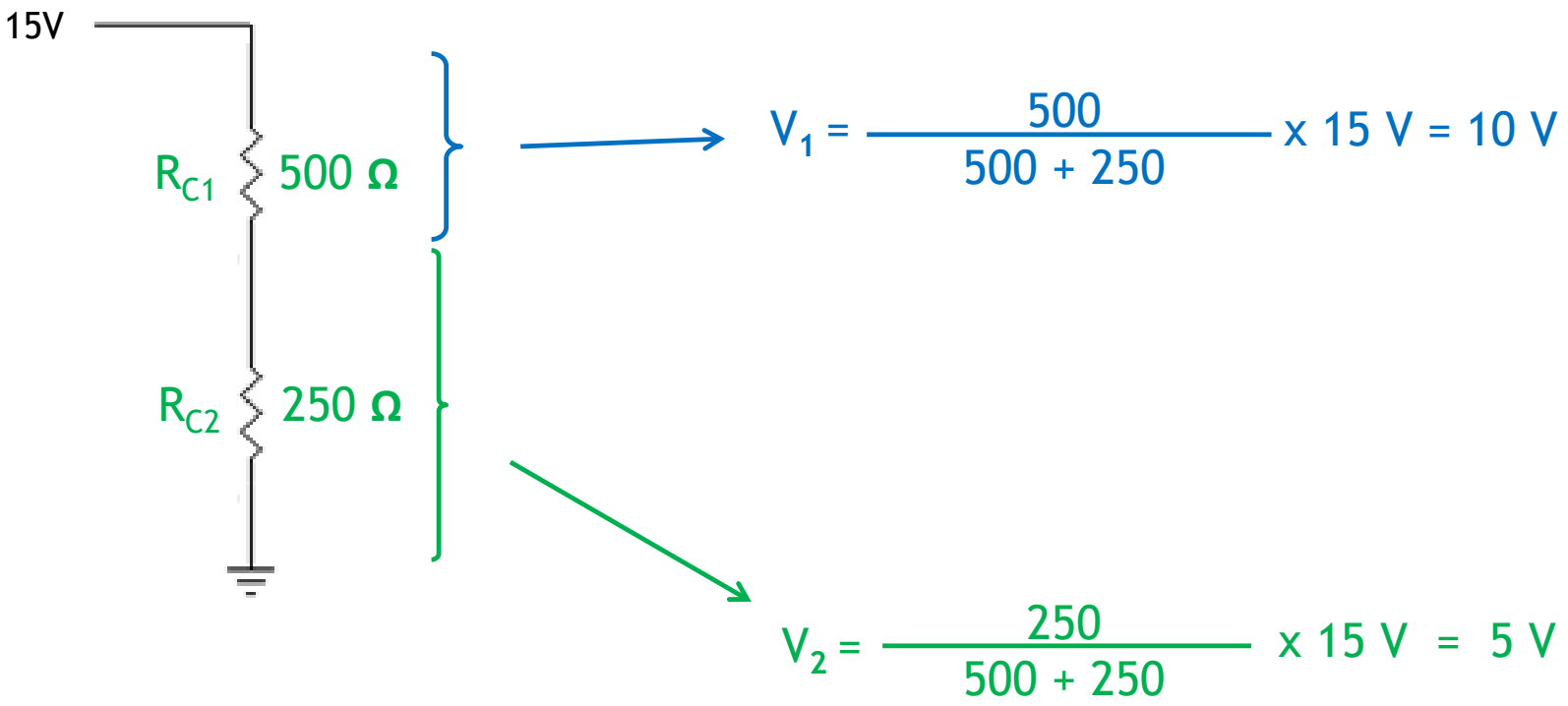
ANSWER

Combined required resistance to form the distribution across the voltage



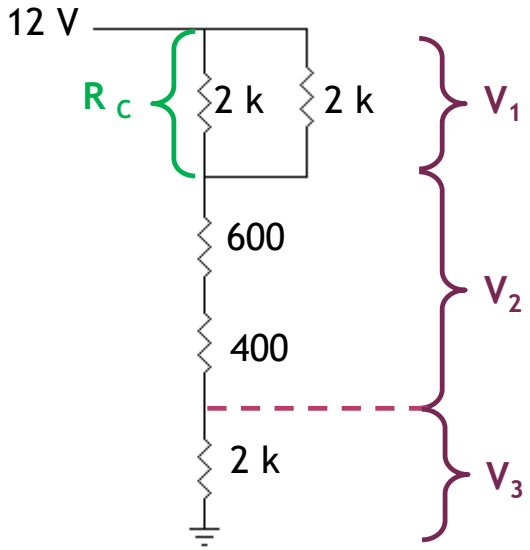
ANSWER

Use Voltage Divider rule to find out the different voltages



STRUCTURED QUESTIONS

Find the combined resistance R_C and use voltage divider to compute V_1, V_2 and V_3.



STRUCTURED QUESTIONS

Find the combined resistance R_{C1} and R_{C2} , use voltage divider to compute V_1 and V_2.