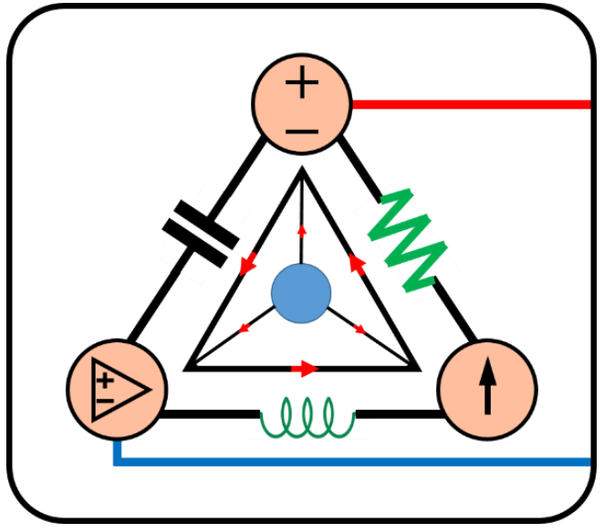
2-Mavzu: Elektr zanjiriga oid asosiy qonunlar.

(Lecture-2: Basic Laws)

2-Mavzuning 1-qismi

(Part 1 of the Lecture-2)



Lecturer: Ph.D., Yusupov Sarvarbek

Toshkent Kimyo Xalqaro Universiteti
“Mashinasozlik texnologiyasi” kafedrasi
Toshkent shahri, Usmon Nosir, 156-uy.

2-Mavzu: Elektr zanjiriga oid asosiy qonunlar.

(Lecture-2: Basic Laws)

O‘quv rejasi:

2.1. Om qonuni.

2.2. Tugun, shaxobcha va kontur.

2.3. Kirxgof qonunlari.

2.4. Ketma-ket ulangan qarshiliklar va kuchlanishni bo‘linish qoidasi.

2.5. Parallel ulangan qarshiliklar va tok kuchini bo‘linish qoidasi.

2.6. Qarshiliklar yulduzini qarshiliklar uchburchagiga (Wye-Delta) o‘zgartirish.

2.7. Qo‘llanilishi.

2.1. Om qonuni.

Kuchlanish (V)

U

Kuchlanish potensiallar farqini ifodalaydi.

$$U = \varphi_1 - \varphi_2$$

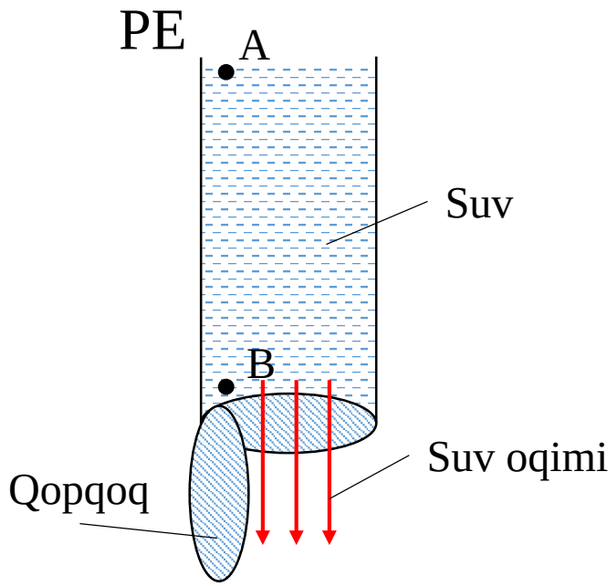
Om qonuni - o‘tkazgichdan o‘tayotgan o‘zgarmas tok kuchi bilan uning uchlaridagi potensiallar farqining o‘zaro bog‘liqligini ifodalovchi qonundir.

Tok kuchi (A)

I

Qarshilik (Ω) (Om)

R



Elektron potensial nima?

- 1 C zaryadning potensial energiyasi;
- 1 C zaryadga to‘g‘ri keluvchi PE.

Tok kuchi (A)

I

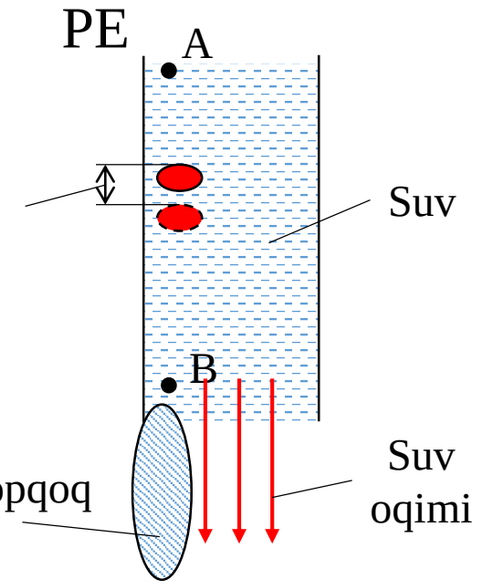
Tok kuchi bu – o‘tkazgichning biror nuqtasidan yoki ko‘ndalang kesim yuzasidan 1 sekundda qancha zaryad o‘tishini bildiradi.

$$I = \frac{q}{t}$$

Kuchlanish (V)

U

t=1 s. Birlik vatq ichida qancha zaryad o‘tkanligini bildiradi.



Qarshilik (Ω) (Om)

R

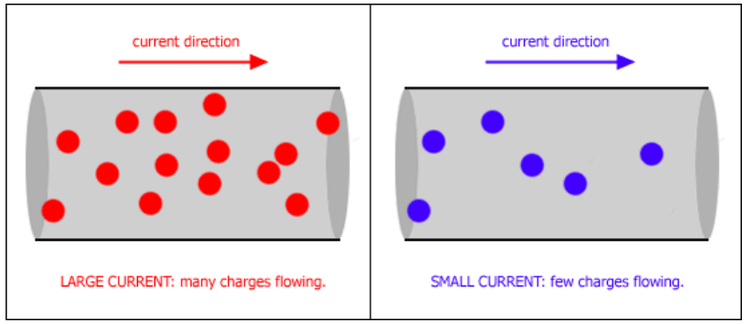


Photo source: [1] - https://kaiserscience.files.wordpress.com/2016/03/small-vs-large-electrical-current1.gif

Qarshilik (Ω) (Om)

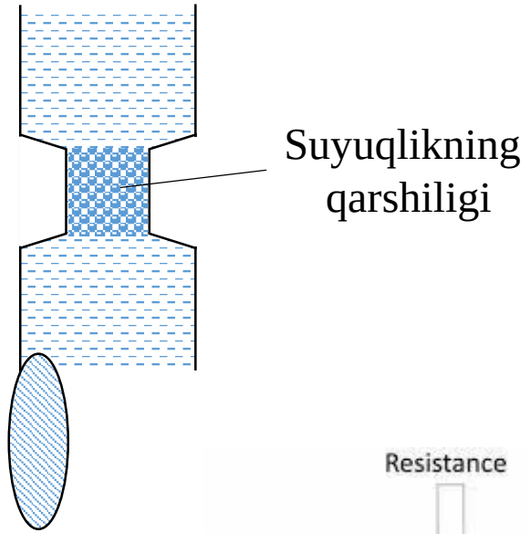
R

Qancha miqdordagi yoki qanday miqdordagi zaryad harakati davomida qarshilikka uchrashi bu elektr qarshiligi deyiladi.

- Qarshilik bo‘lganligi uchun bir xil vaqtda kamroq suv oqadi.

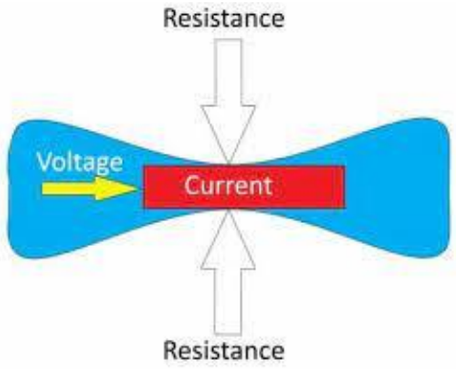
Kuchlanish (V)

U



Tok kuchi (A)

I



Elektr qarshilik tushunchasi:

O‘tkazgichning atomlari tomonidan elektr zayadini tashuvchi zarrachalarga qarshilik ko‘rsatiladi.

- Bu jarayon to‘qnashuvlar hisobiga bo‘ladi.

Photo source: [2] - https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcS4-nV0-C0OjNyzDtgR9ub-sgOMYdO16d0e6dvYPx7Vc97Or8_xJ7UUCc0aE929M7hwhZQ&usqp=CAU

Materiallar elektr zaryadining oqimiga qarshilik ko‘rsatadigan xususiyatga ega.

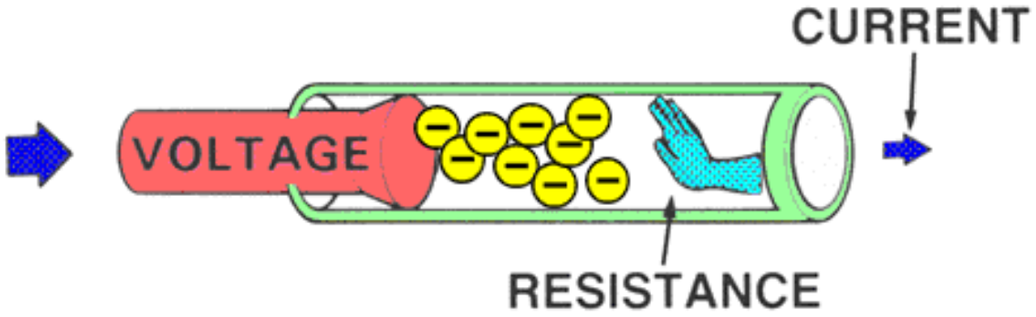


Photo source: [3] - https://1.bp.blogspot.com/-FokgDwMszuc/XbRy5vWcuSI/AAAAAAAAAKY/Ywgu8bXYNi0MDgbMYZjDv-vbhv6UZMaZACLcBGAsYHQ/s1600/resist3.gif

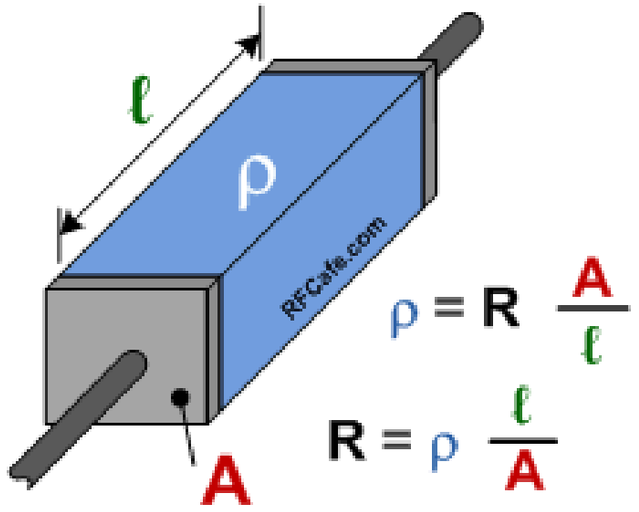


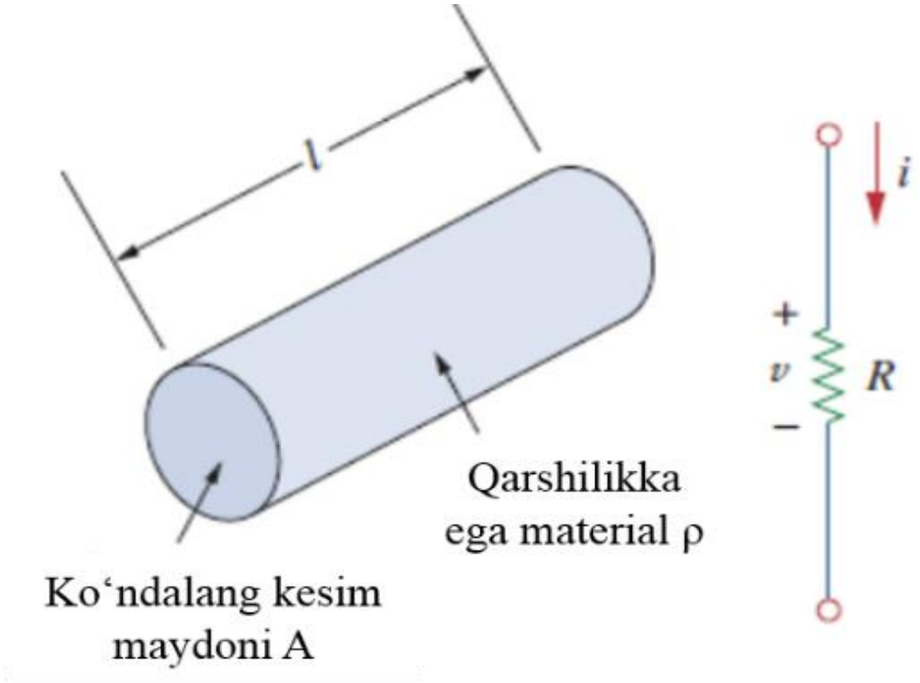
Photo source: [4] - https://www.rfcafe.com/references/electrical/images2/resistivity.gif

Ko‘ndalang kesim yuzasi (*A)* bo‘lgan har qanday qarshilikka ega material zichligi (ρ) ning va uning uzunligi (*l)* ga bog‘liq (2.1-rasm, a). Biz qarshilikni quyidagi matematik shaklda ifodalaymiz:

$$\boldsymbol{R = \rho \frac{l}{A}} \qquad (2.1)$$

bu yerda: *ρ* - materialning qarshiligi Omda.

SI da o‘tkazuvchanlik birligi qilib simens (S) qabul qilingan.



a) b)

2.1-rasm.

a) qarshilik; b) qarshilikni elektr zanjiridagi shartli belgisi.

O‘tkazuvchanlik - elementning elektr tokini o‘tkazish qobiliyatidir.

1 simens (S) deb, uchlarida 1 V kuchldanish bo‘lganda 1 A tok o‘tadigan o‘tkazgichning o‘tkazuvchanligiga aytiladi.

Odatda, amaliy hisoblashlarda o‘tkazuvchanlikning teskari ifodasi bo‘lgan kattalikdan foydalaniladi va unga o‘tkazgichning qarshiligi deyiladi:

$$R = \frac{1}{G} \qquad (2.2)$$

Photo source: [5] - Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., -2013. – 30 (905) p.

Materiallarning qarshiligi yoki o‘tkazuvchanligi quyidagi xususiyatlarga ega:

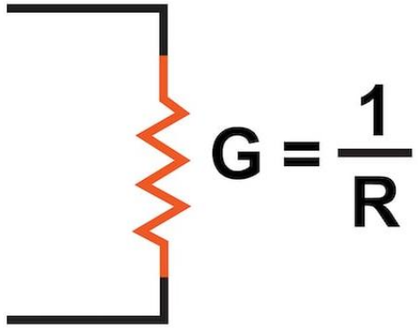


Photo source: [6] - https://www.allaboutcircuits.com/uploads/thumbnails/conductance_thumbnail.jpg

- yaxshi o‘tkazgichlar past qarshilikka ega, **G ↑ R ↓**
- izolyatorlar esa yuqori qarshilikka ega. **G ↓ R ↑**

Umumiy materiallarning qarshiligi 2.1-jadval

Material	Qarshiligi (Om)	Ishlatilishi
Kumush	$1{,}64 * 10^{-8}$	o‘tkazgich
Mis	$1{,}72 * 10^{-8}$	o‘tkazgich
Alyuminiy	$2{,}8 * 10^{-8}$	o‘tkazgich
Oltin	$2{,}45 * 10^{-8}$	o‘tkazgich
Uglerodli	$4 * 10^{-5}$	yarim o‘tkazgich
Germaniy	$47 * 10^{-2}$	yarim o‘tkazgich
Silikon	$6{,}4 * 10^{-2}$	yarim o‘tkazgich
Qog'oz	10^{10}	izolyator
Slyuda	$5 * 10^{11}$	izolyator
Shisha	10^{12}	izolyator
Teflon	$3 * 10^{12}$	izolyator

Rezistor eng oddiy passiv element hisoblanadi.

Materialning oqimga chidamli harakatini modellashtirish uchun ishlatiladigan elektron element ***rezistordir***. Elektr zanjirlarni qurish uchun rezistorlar odatda metall qotishmalardan va uglerod birikmalaridan tayyorlanadi.

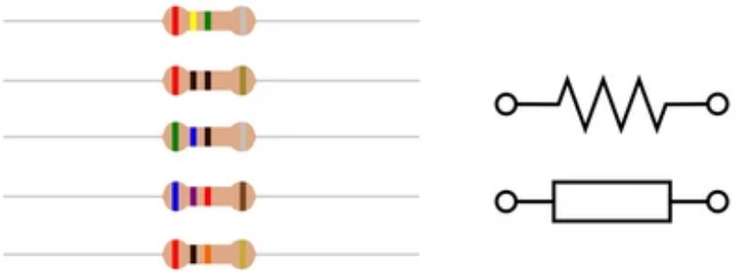


Photo source: [7] - https://www.shutterstock.com/image-vector/resistor-isolated-electrical-parts-vector-260nw-1562914033.jpg

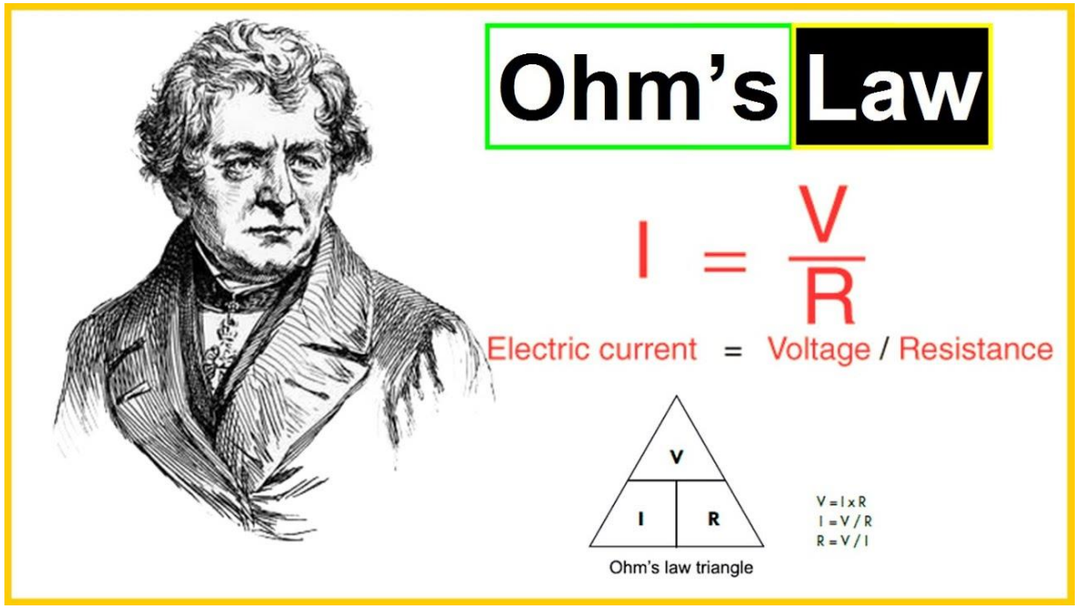


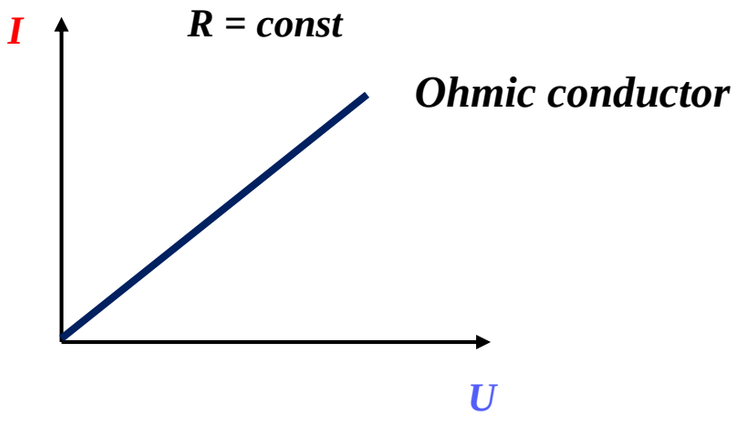
Photo source: [8] - https://i.ytimg.com/vi/sR_uPI08a9c/maxresdefault.jpg

Nemis fizigi Georg Simon Om (1787-1854) rezistor uchun tok kuchi va kuchlanish o‘rtasidagi bog‘liqlikni topgan.

Bu munosabatlar Om qonuni sifatida tanilgan.

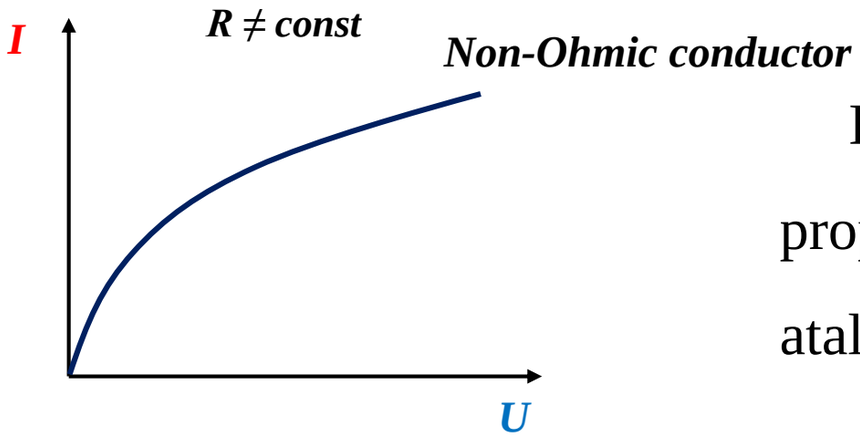
Om qonuni shuni ko‘rsatadiki, rezistordagi U kuchlanish rezistordan o‘tadigan tok kuchi I ga to‘g‘ridan-to‘g‘ri proporsionaldir. Ya’ni,

$$U \propto I \tag{2.3}$$



Om qonuni ko‘plab o‘tkazgichlarni aniq tasvirlaydi.

Ushbu qonunga amal qiladigan materiallar “omik” deb nomlanadi.



Biroq, tok kuchi va kuchlanish farq to‘g‘ridan-to‘g‘ri proporsional bo‘lmagan har qanday o‘tkazgich “nonomik” deb ataladi.

Graph and text source: [9] - https://www.nagwa.com/en/explainers/927152480586/

Shunday qilib, (2.3) ifoda quyidagi ko‘rinishga ega.

$$U = I \cdot R \tag{2.4}$$

(2.4) tenglamadan xulosa qiladigan bo‘lsak,

$$R = \frac{U}{I} \tag{2.5}$$

Ohms Law Triangle

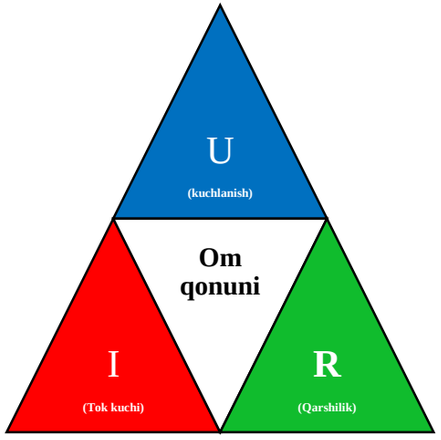
$U = I \cdot R$

I → **U** ga to‘g‘ri proporsional.

U ↑ **I** ↑

I → **R** ga teskari proporsional.

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



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

Zanjirning bir qismi uchun Om qonuniga ko‘ra:

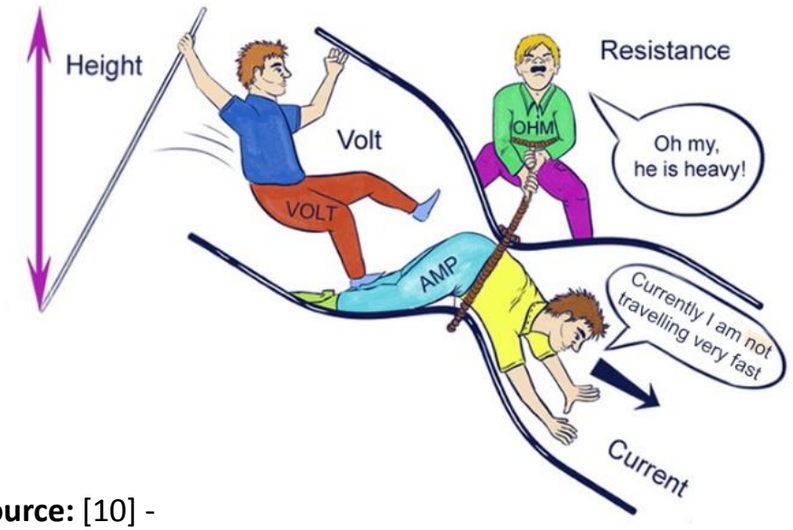
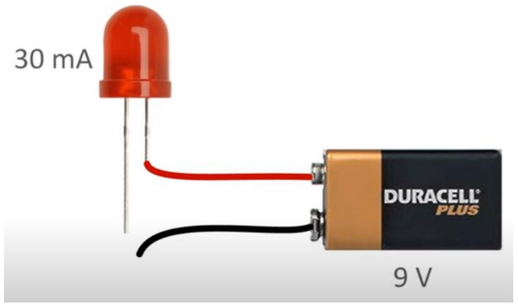


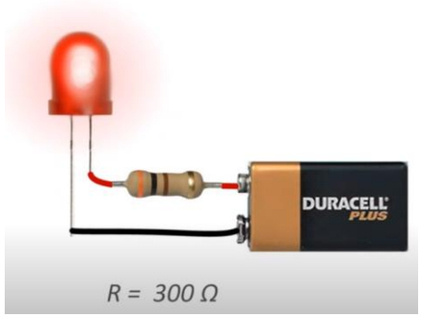
Photo source: [10] - https://mammothmemory.net/images/user/base/Physics/Electricity/Ohms%20law/ohms-law.c1c09ec.jpg

Kattalik	Belgilanishi	O‘lchov birligi
Tok kuchi	I	Amper (A)
Kuchlanish	U yoki E	Volt (V)
Qarshilik	R	Om (Ω)

Photo source: [11] - https://static.wixstatic.com/media/4cbe06_fed4edf5660c483ba4081eb6709029a2~mv2.jpg/v1/fill/w_640,h_426,al_c,lg_1,q_80,enc_auto/4cbe06_fed4edf5660c483ba4081eb6709029a2~mv2.jpg

Example:





$R = ?$ $\quad R = \frac{U}{I} \quad R = \frac{9}{0{,}03} = 300\ \Omega$

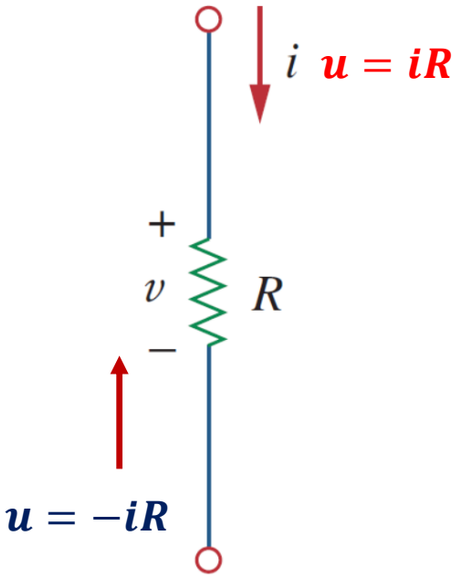
Example source: [12] - https://www.youtube.com/watch?v=Gc1wVdbVI0E

2.1.1-masala: Elektr dazmol 120 V da 2 A tok iste’mol qiladi. Uning qarshiligini toping?

Yechish: Om qonunidan foydalanib,

$$R = \frac{u}{i} = \frac{120}{2} = 60\ \Omega$$

Demak, Om qonunini qo‘llash uchun biz tok kuchi yo‘nalishi va kuchlanish qutblariga diqqat bilan e’tibor berishimiz kerak. Tok kuchining yo‘nalishi va kuchlanishning qutblari **PASSIV ISHORA KONVENSIYASI**ga mos kelishi kerak.



2.1-rasm, b

Bu shuni anglatadiki, $\boldsymbol{u = iR}$ bo‘lishi uchun tok kuchi yuqori potensialdan pastroq potensialga o‘tadi.

Quvvat sarf bo‘ladi.

Agar tok kuchi pastroq potentsialdan yuqori potensialga o‘tsa, $\boldsymbol{u = -iR}$.

Quvvat ta’minlanadi.

Photo source: [5] - Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., -2013. – p 30.

R ning qiymati noldan cheksizgacha bo‘lishi mumkinligi sababli, R ning ikkita o‘ta mumkin bo‘lgan qiymatini ko‘rib chiqish muhimdir.

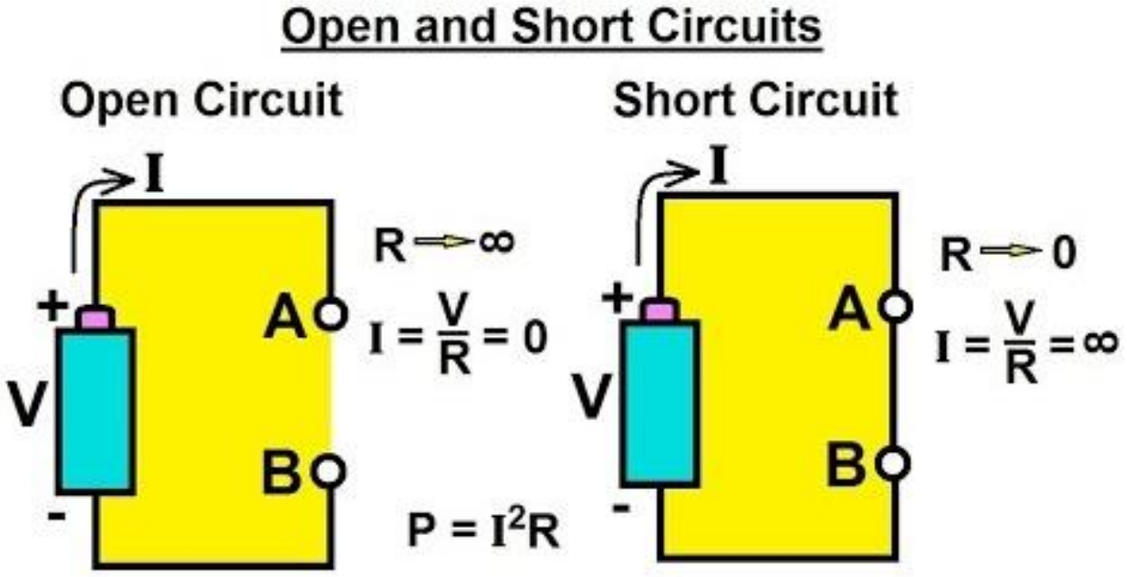
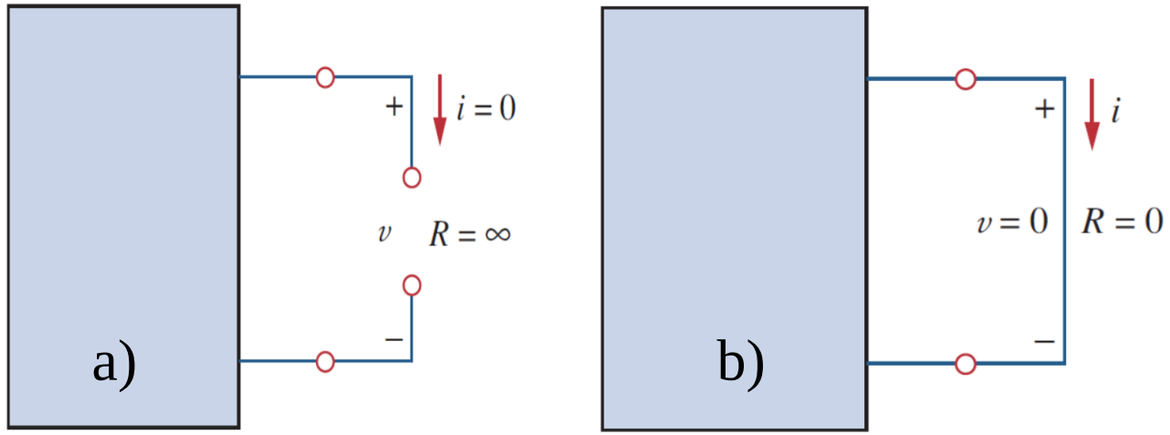


Photo source: [13]
https://i.ytimg.com/vi/cgtSKaVTPmY/hqdefault.jpg

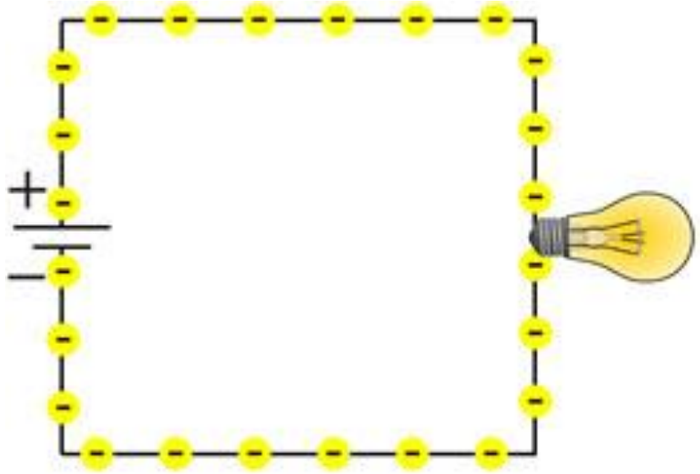
Ochiq zanjir **Qisqa tutashuv zanjir**



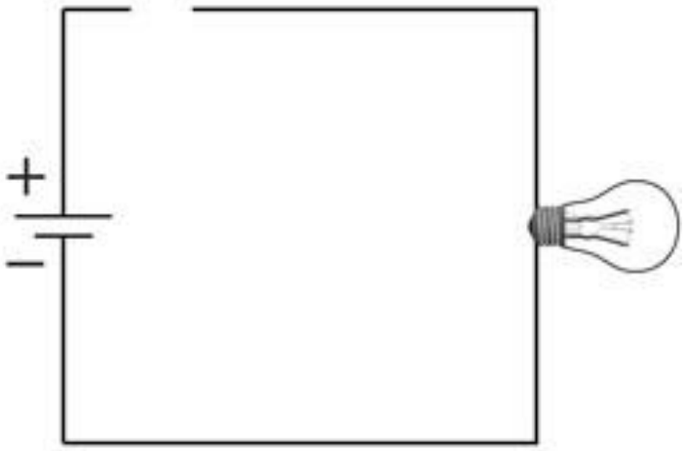
2.2-rasm.

$$i = \lim_{R \to \infty} \frac{u}{R} = 0 \quad (2.6) \qquad u = iR = 0 \quad (2.7)$$

Photo source: [14] - Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., -2013. – p 32.

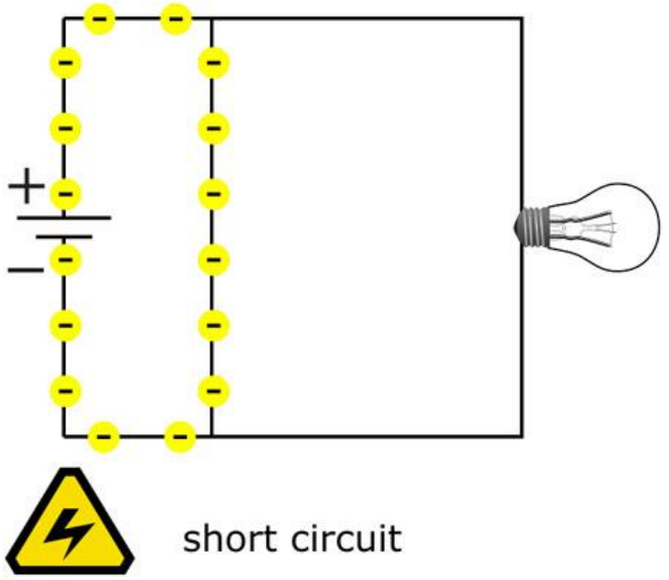


closed circuit



open circuit

Photo source: [15] - https://www.dummies.com/wp-content/uploads/489264.image0.jpg



short circuit

Photo source: [16] - https://www.dummies.com/wp-content/uploads/489267.image3.jpg

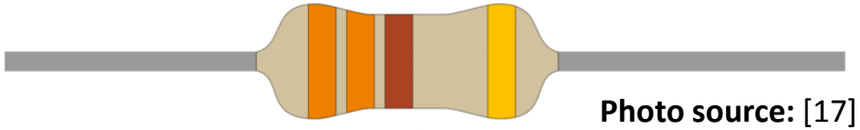


Photo source: [17] - https://www.electrokit.com/uploads/productimage/40810/40810233.png

Doimiy **O‘zgaruvchan**

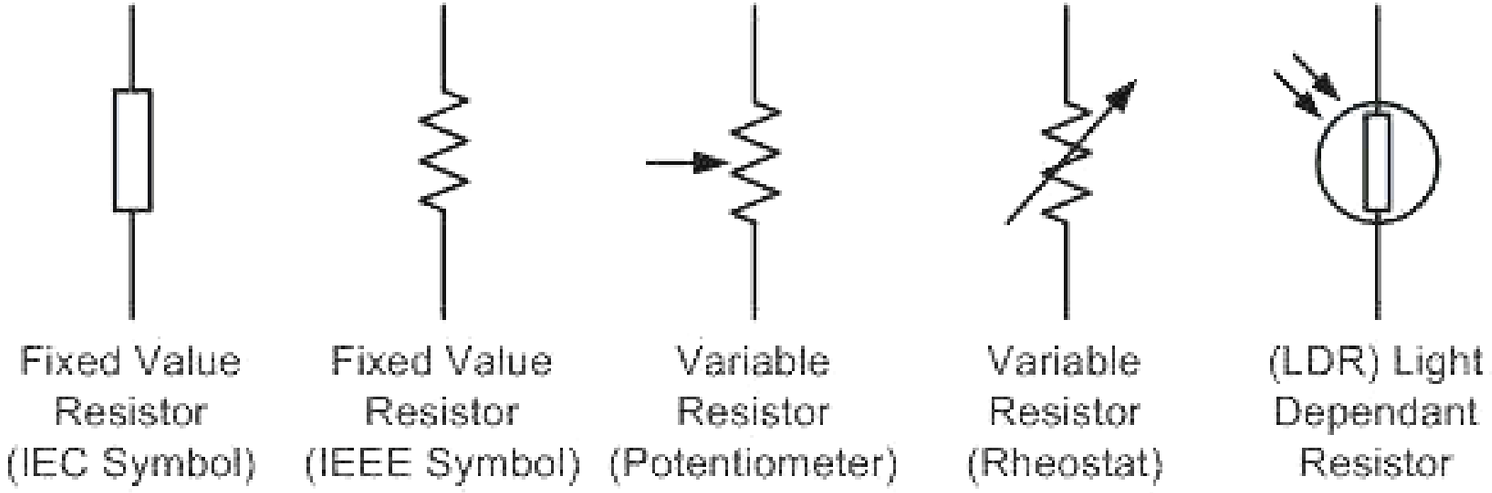
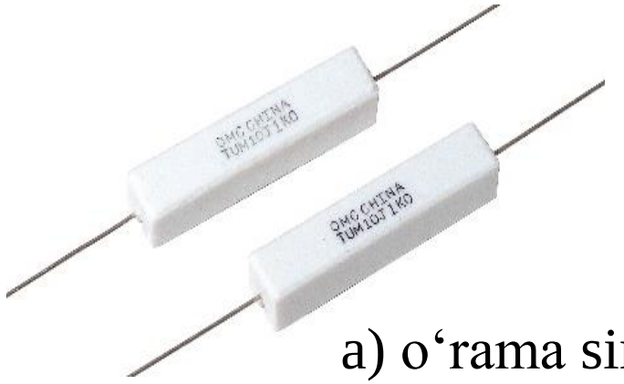


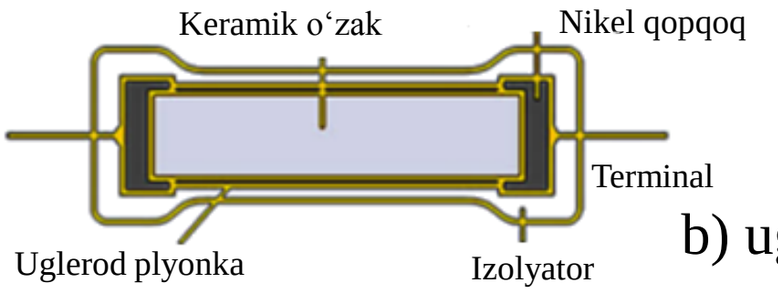
Photo source: [18] - https://components101.com/sites/default/files/inline-images/Resistor-Symbols.png

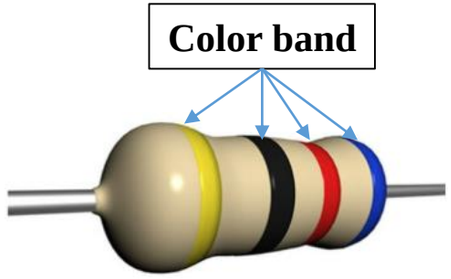


a) o‘rama simli;
(wire-wound type)

Photo source: [19] - https://www.ohmite.com/assets/images/buckets/TUM_1-updated.jpg

Kompozitsion rezistorlar katta qarshilik kerak bo‘lganda ishlatiladi.





b) uglerod plyonkali turi.
(carbon film type)

Photo source: [20] - https://blogmedia.testbook.com/blog/wp-content/uploads/2022/10/parts-of-carbon-resistor-39aec770.png

2.3-rasm. Doimiy rezistorlar *(fixed resiztors)*:

How to read Resistor Color Codes?

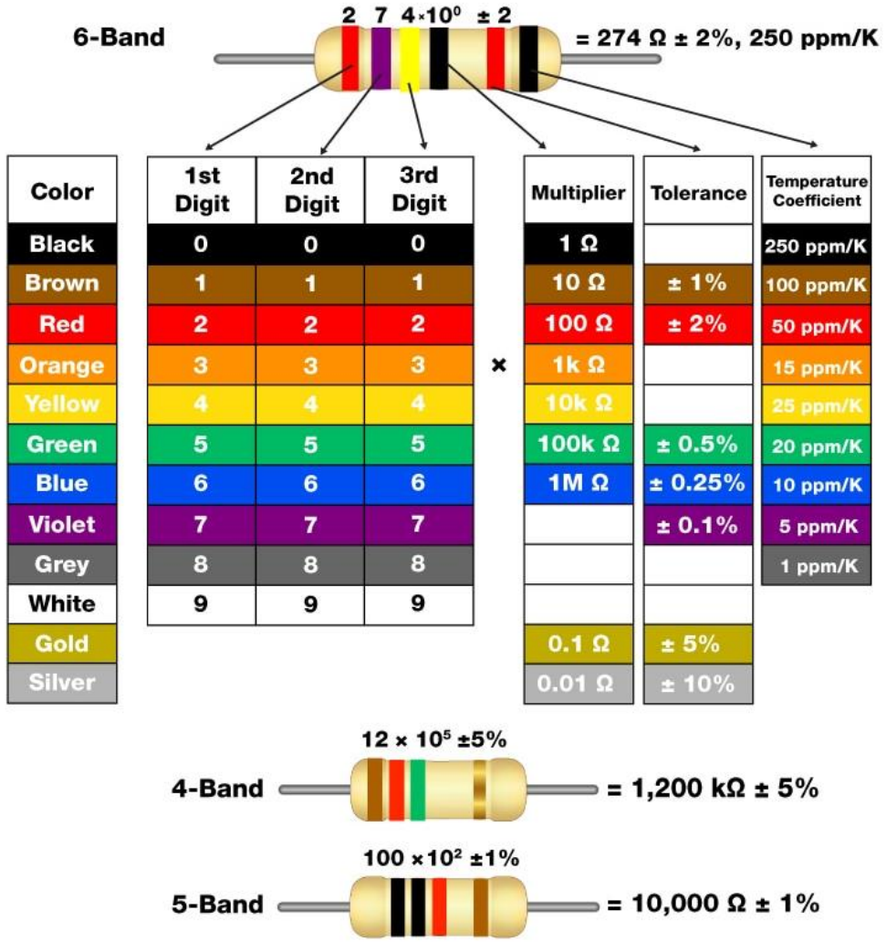


Photo source: [21] - https://static4.arrow.com/-/media/arrow/images/miscellaneous/h/how-to-read-resistor-color-codes.jpg

Ohms Law Pie Chart – Ohm qonun doirasi diagrammasi

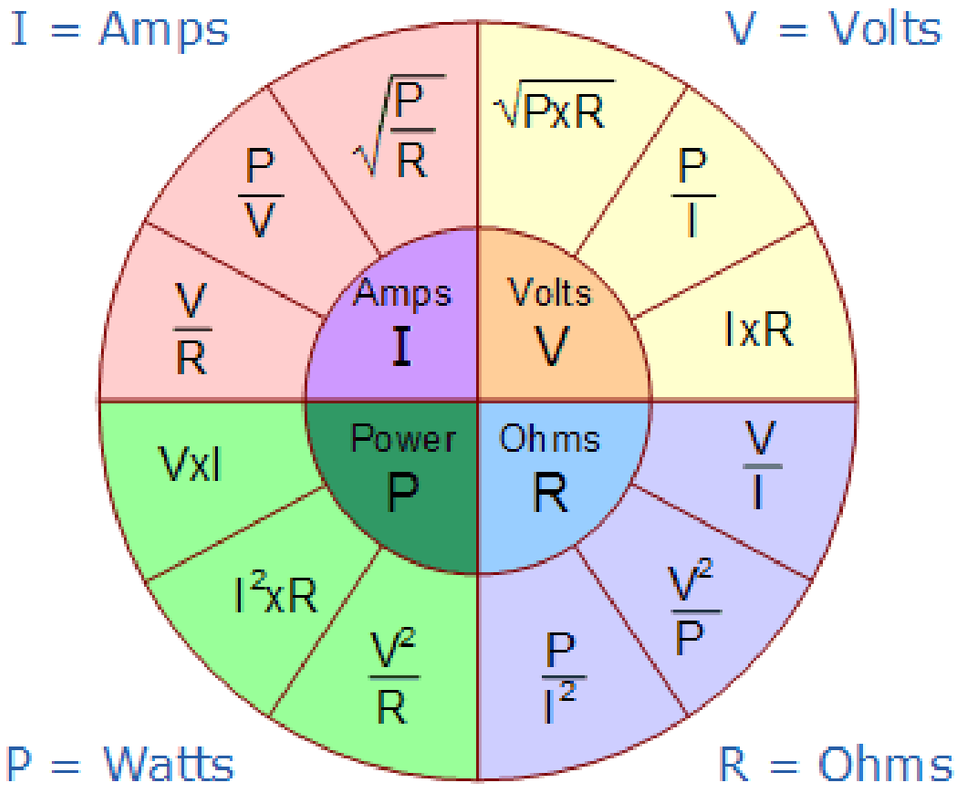


Photo source: [22] - https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/dccircuits-dcp4.gif

O‘zgaruvchan rezistorlar sozlanuvchan qarshilikka ega.

a) b)

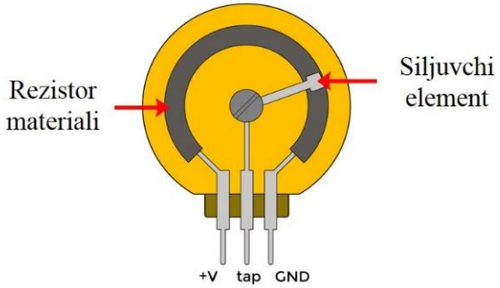
2.4-rasm. Rezistorning zanjirdagi belgisi:

a) umumiy o‘zgaruvchan rezistor;

b) potensiometrli rezistor.

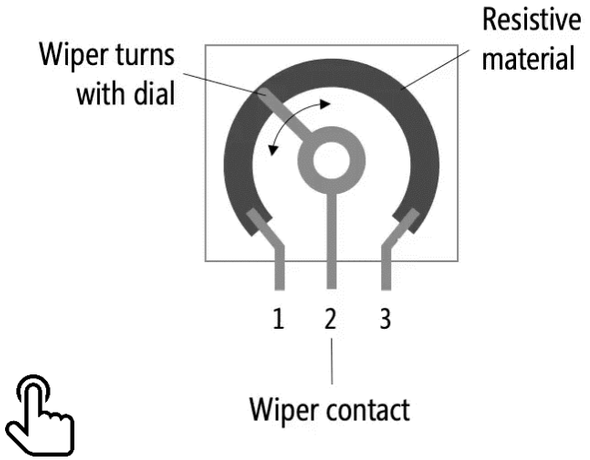
Potensiometr kontaktli uch terminalga ega elementdan tashkil topgan.

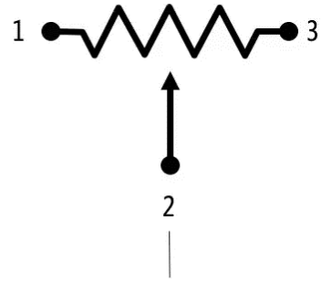
Kompozitsion turi



2.5-rasm.

Photo source: [23] - https://www.circuitbasics.com/wp-content/uploads/2020/05/How-a-Potentiometer-Works-1024x655.png





Video source: [24] - ttps://makeabilitylab.github.io/physcomp/electronics/assets/videos/Potentiometer_Overview_ByJonFroehlich.mp4

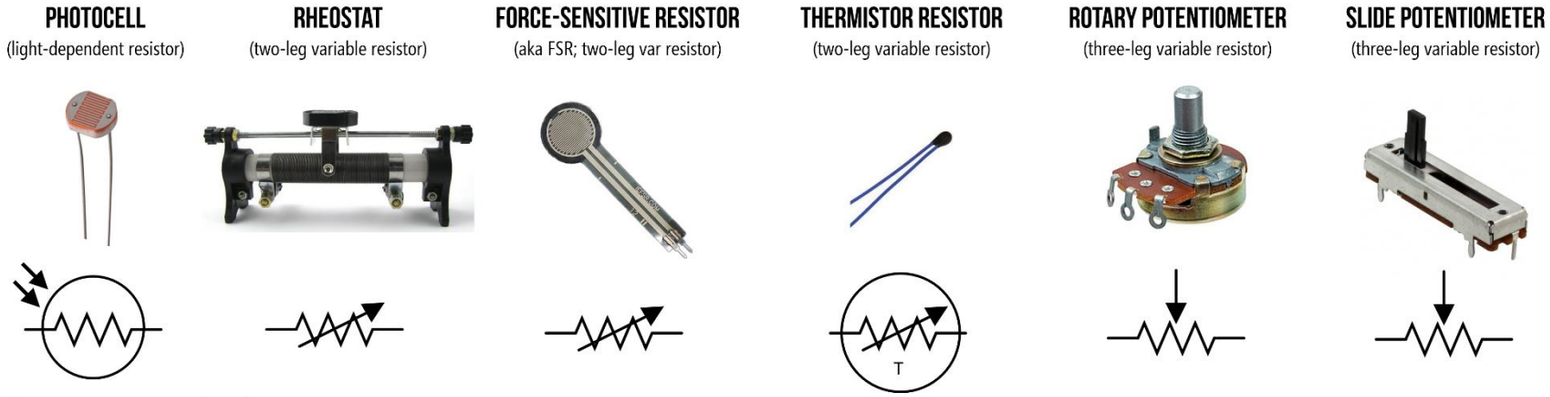
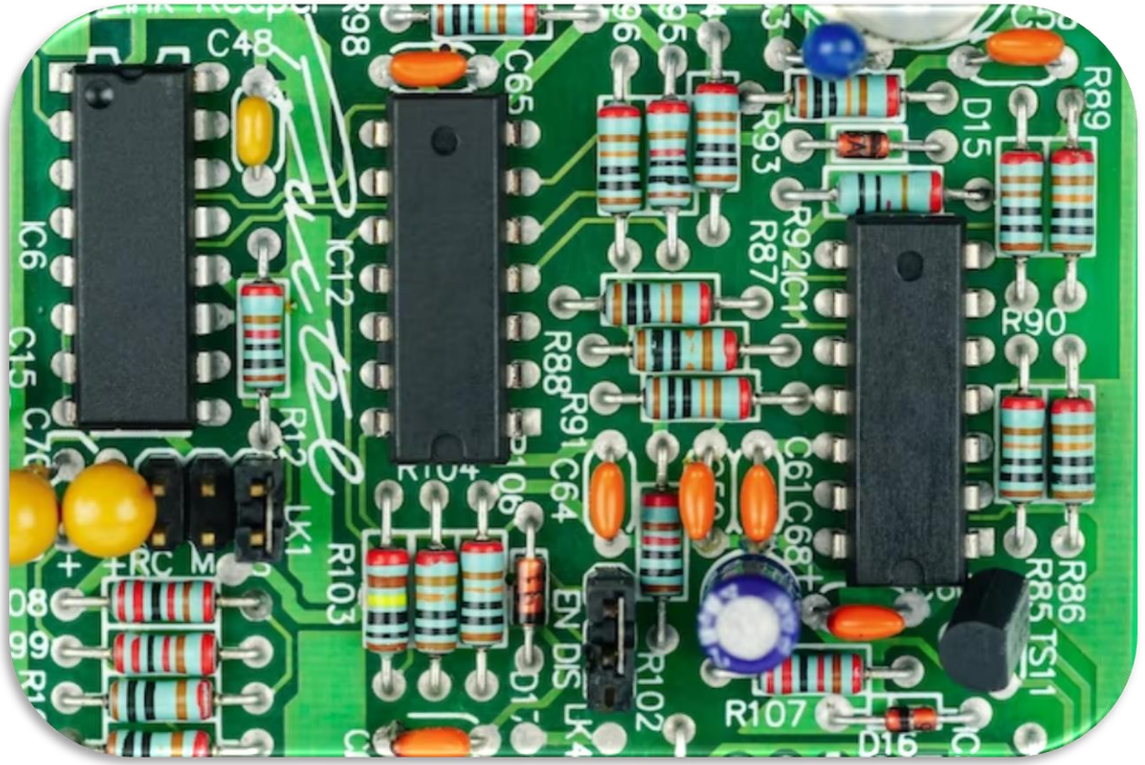


Photo source: [25] - https://makeabilitylab.github.io/physcomp/electronics/assets/images/SchematicSymbolsOfVariableResistors_ByJonFroehlich.png

Slayder potensiometr

Photo source: [26] - https://probots.co.in/pub/media/catalog/product/cache/ca2cd736c0c15942c77daffc8cf27b66/1/k/1k_ohm_variable_resistor_potentiometer1-1000x1000.jpg



2.6-rasm. Integratsiyalashgan elektron platadagi rezistorlar.

Photo source: [28] - https://img.freepik.com/premium-photo/closeup-printed-circuit-board-with-components-such-as-resistors-integrated-circuits_483511-3552.jpg

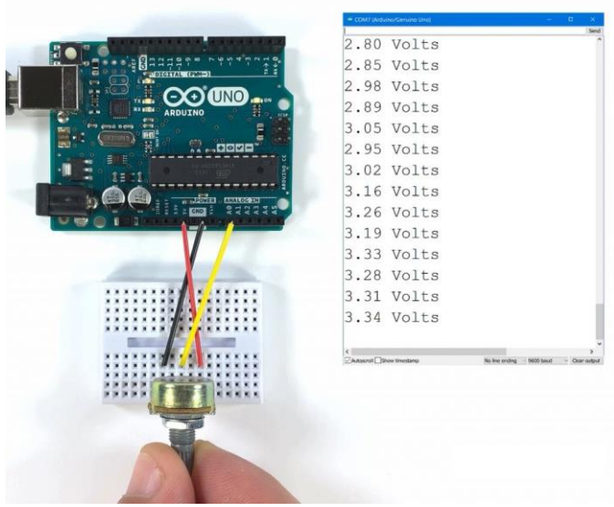
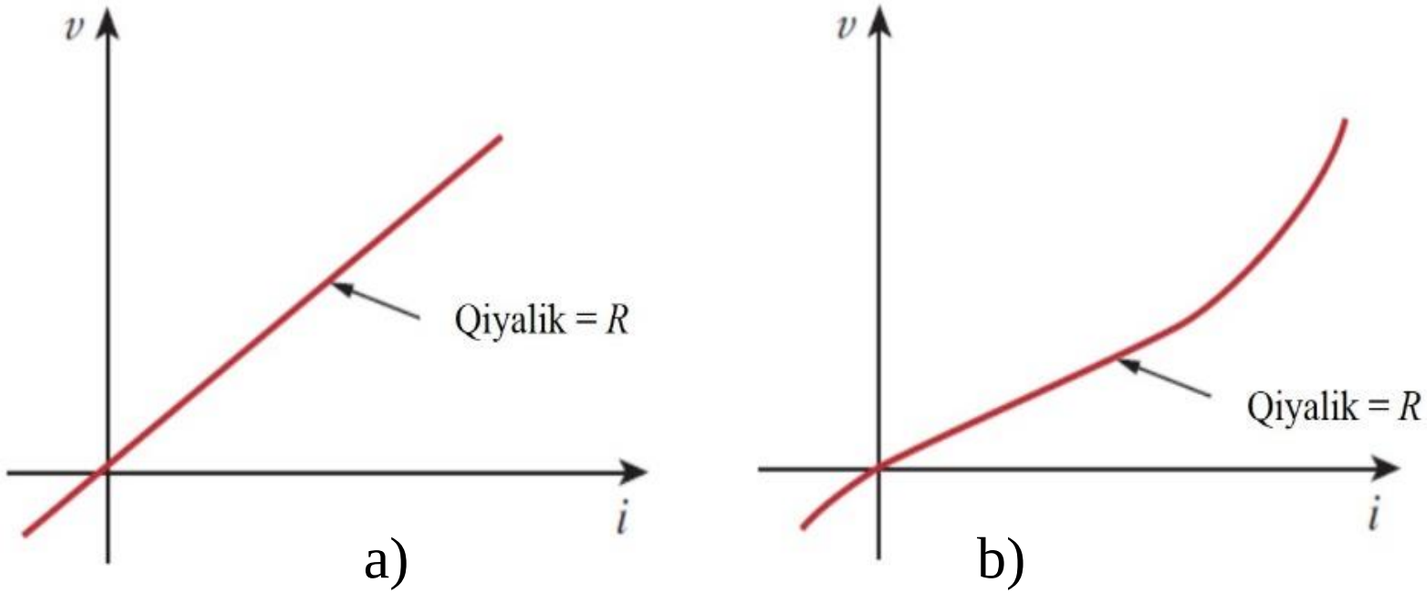


Photo source: [27] - https://www.circuitbasics.com/wp-content/uploads/2020/05/Potentiometer-Voltage-Output-on-Arduino-Serial-Monitor-1024x848.jpg



2.7-rasm. Rezistorning *i* – *u* tavsifi:

a) chiziqli rezistor; b) chiziqli bo‘lmagan rezistor.

Chiziqli bo‘lmagan qarshilikka - **lampochka** va **diod**lar misol bo‘la oladi.

Zanjir tahlilida foydali miqdor *R* qarshiligining o‘zaro nisbati bo‘lib, u o‘tkazuvchanlik deb nomlanadi va *G* bilan belgilanadi:

$$\boldsymbol{G = \frac{1}{R} = \frac{i}{u}} \qquad (2.8)$$

$$\boldsymbol{1\ S = 1\ \text{℧} = 1\ A/V} \qquad (2.9)$$

10 Ω = 0,1 S

$$\boldsymbol{i = Gu} \qquad (2.10)$$

(1.14) va (2.4) tenglamalar yordamida ifodalanishi mumkin.

$$p = u \cdot i = i \cdot R \cdot i = i^2 \cdot R = \frac{u^2}{R} \qquad (2.11)$$

Rezistor tomonidan tarqaladigan quvvat G sifatida ham ifodalanishi mumkin.

$$p = u \cdot i = u \cdot u \cdot G = u^2 G = \frac{i^2}{R} \qquad (2.12)$$

The Power Triangle

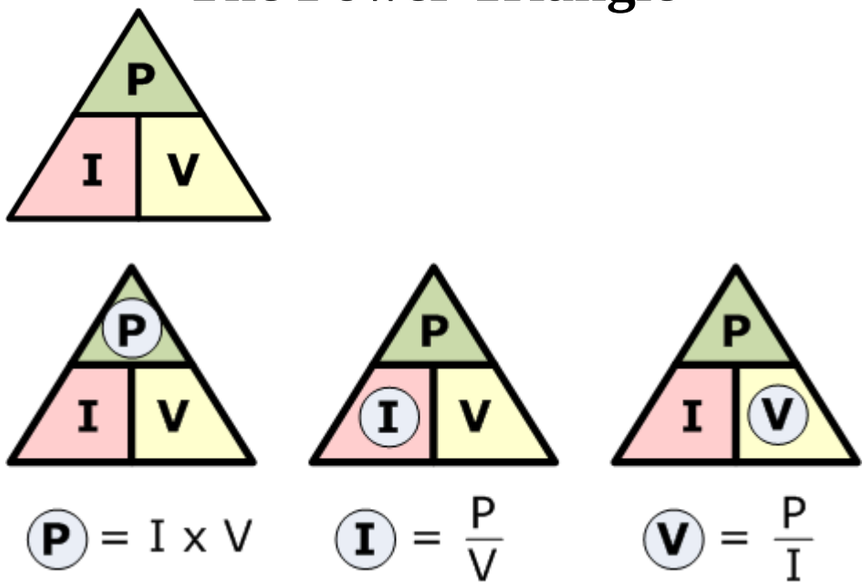


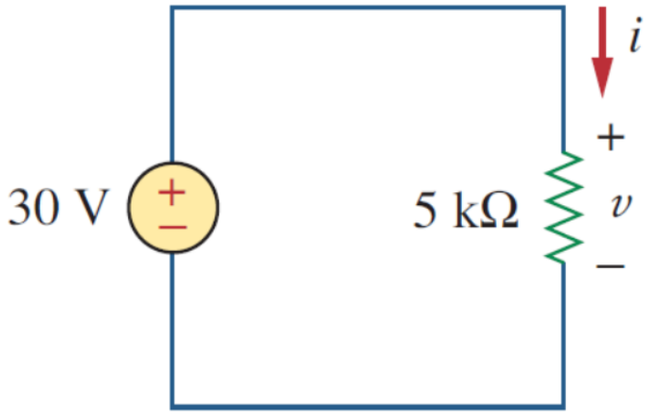
Photo source: [29] - https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/dccircuits-dcp25.gif

Ohms Law Matrix Table

Ohms Law Formulas				
Known Values	Resistance (R)	Current (I)	Voltage (V)	Power (P)
Current & Resistance	---	---	$V = IxR$	$P = I^2xR$
Voltage & Current	$R = \frac{V}{I}$	---	---	$P = VxI$
Power & Current	$R = \frac{P}{I^2}$	---	$V = \frac{P}{I}$	---
Voltage & Resistance	---	$I = \frac{V}{R}$	---	$P = \frac{V^2}{R}$
Power & Resistance	---	$I = \sqrt{\frac{P}{R}}$	$V = \sqrt{PxR}$	---
Voltage & Power	$R = \frac{V^2}{P}$	$I = \frac{P}{V}$	---	---

Photo source: [30] - https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/dccircuits-dcp4a.gif

2.1.2-masala: 2.8-rasmda ko‘rsatilgan zanjirning tok kuchi i, o‘tkazuvchanligi G va quvvati p ni hisoblang.



2.8-rasm.

Demak, tok kuchi

$$i = \frac{u}{R} = \frac{30}{5 \cdot 10^3} = 6\ mA$$

O‘tkazuvchanlik,

$$G = \frac{1}{R} = \frac{1}{5 \cdot 10^3} = 0{,}2\ mS$$

Quvvatni turli usullar bilan hisoblashimiz mumkin.

$$p = ui = 30(6 \cdot 10^{-3}) = 180\ mW$$

$$p = i^2R = (30 \cdot 10^{-3})^2 5 \cdot 10^3 = 180\ mW$$

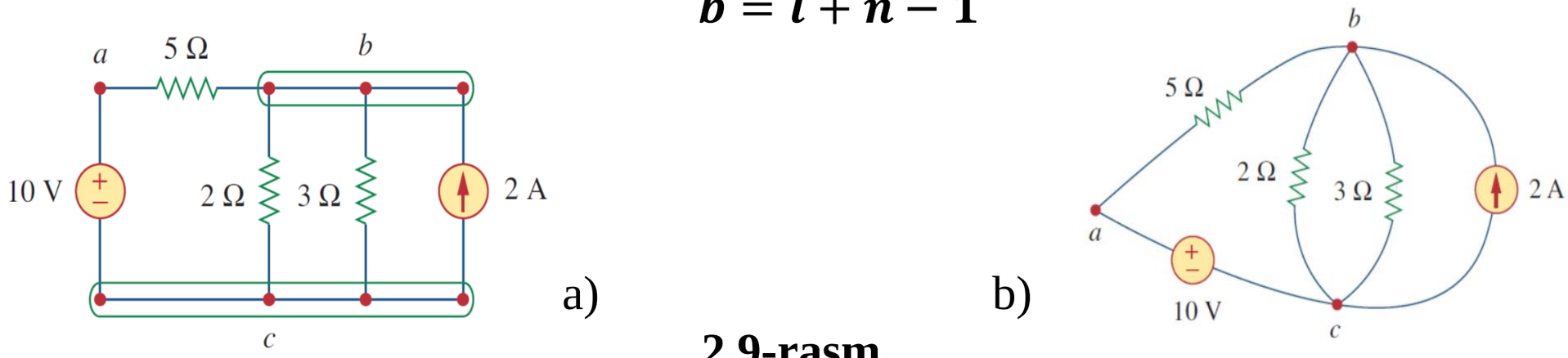
$$p = u^2G = (30)^2 0{,}2 \cdot 10^{-3} = 180\ mW$$

2.2. Tugun, shaxobcha va kontur.

Elektr zanjiridagi elementlarni joylashtirish va tarmoqning geometrik konfiguratsiyasi bilan bog‘liq xususiyatlarni o‘rganishimizda shaxobchalar *(branches)*, tugunlar *(nodes)* va halqalar *(loops)* haqida umumiy ma’lumotga ega bo‘lishimiz kerak.

b shaxobchalar, *n* tugunlar va *l* mustaqil halqalari bo‘lgan tarmoq topologiyasining asosiy teoremasini qanoatlantiradi:

$$\boldsymbol{b = l + n - 1} \qquad (2.13)$$

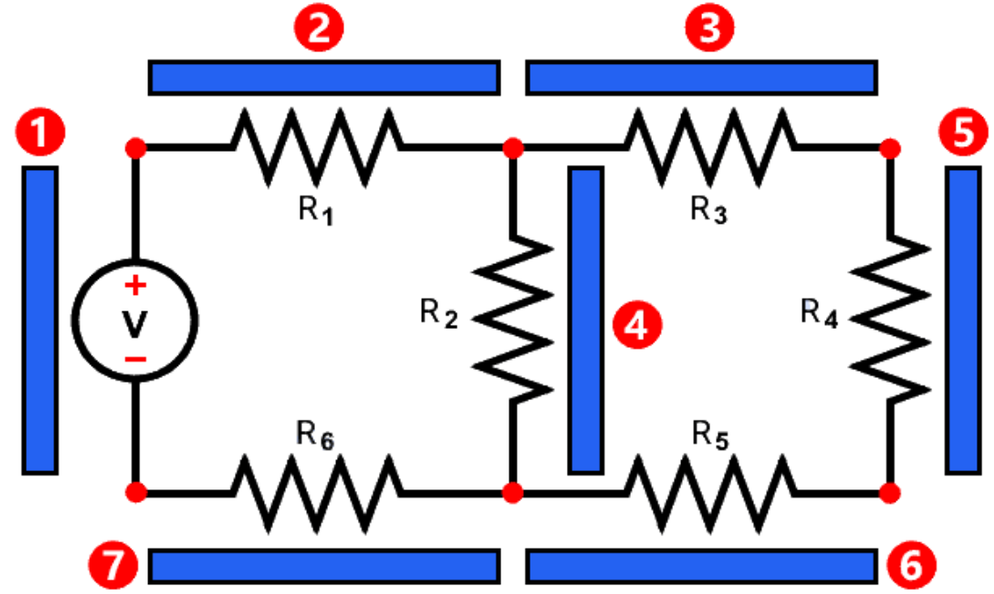


2.9-rasm.

a) tugunlar, shaxobchalar va halqalar; b) *a* ni uch tugunli zanjirini qayta chizilgan holati.

Ikki tugun oralig‘iga ketma-ket ulangan elementlardan iborat bir xil tok o‘tadigan zanjirning qismi **shaxobcha** deb ataladi (2.10-rasm, a).

Shaxobcha tarkibida ixtiyoriy miqdordagi ketme-ket ulangan qarshilik, kondensator, induktivlik elementlari, EYuK manbalari bo‘lishi mumkin.



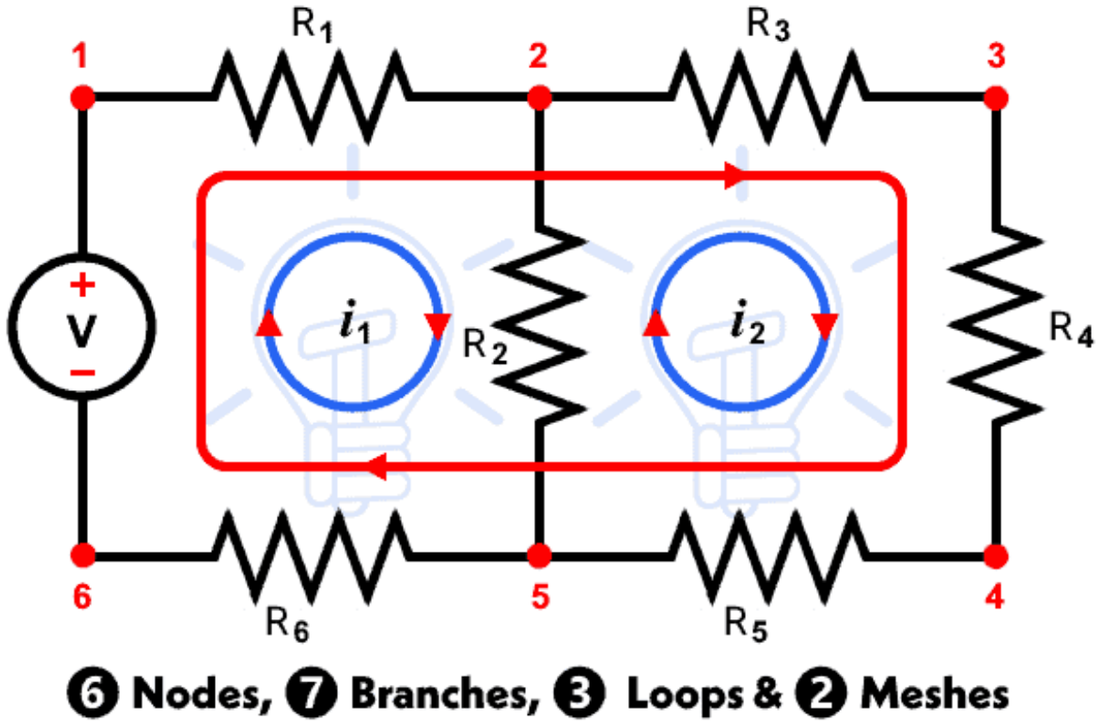
a)

2.10-rasm.
a) elektr zanjirining shaxobchasi;

Photo source: [31] - https://www.electricaltechnology.org/wp-content/uploads/2013/12/How-to-Find-the-Number-of-Branches-in-an-Electric-Circuit.png

Kamida uchta shaxobcha birlashgan nuqta esa, elektr zanjirining **tuguni** deyiladi.

Elektr zanjirining **konturi** deb, bir necha ketma-ket shaxobchalar orqali o‘tgan ixtiyoriy berk yo‘lga aytiladi (2.10-rasm, b 1,2,5,6,1; 2,3,4,5,6).



b)

2.10-rasm.
b) elektr zanjirining tuguni.

Photo source: [32] - https://www.electricaltechnology.org/wp-content/uploads/2013/12/How-to-Determine-the-Number-of-Nodes-Loops-Branches-and-Meshes-in-a-Circuit-.png

Yuqoridagi zanjir elementlarining ta’riflaridan ko‘rinib turibdiki, zanjir topologiyasi elektr zanjiridagi kuchlanish va tok kuchlarini o‘rganish uchun katta ahamiyatga ega.

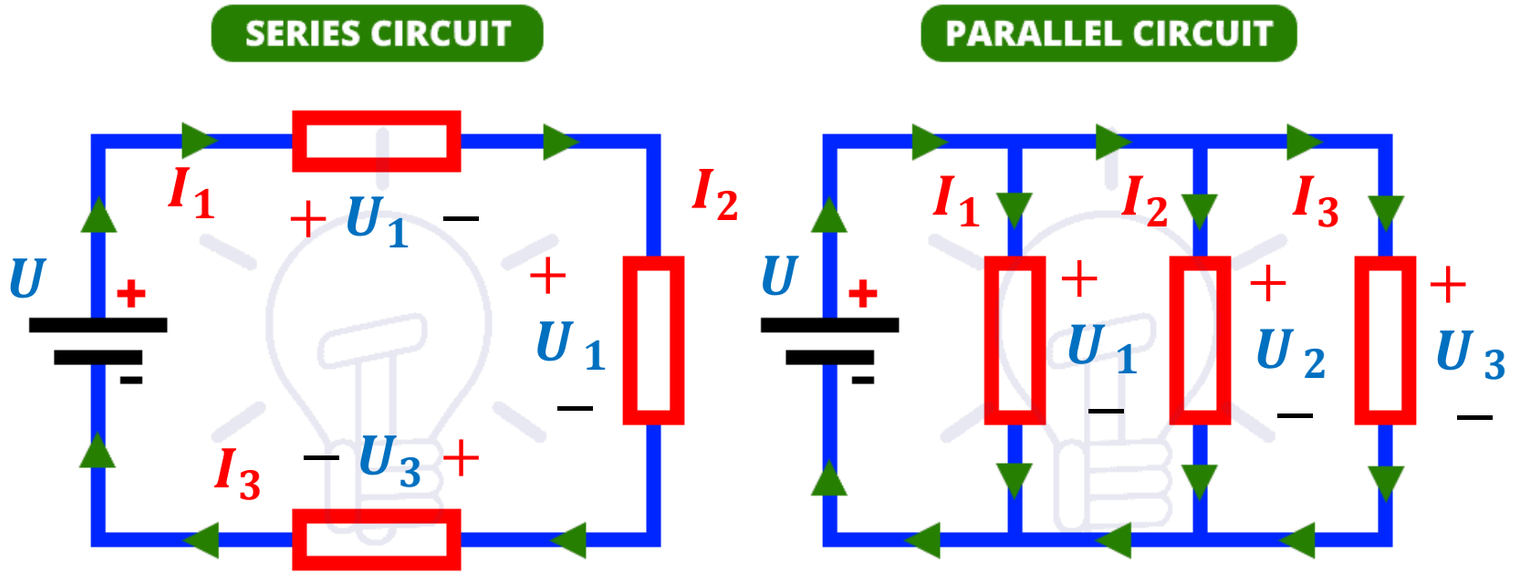
Zanjir elementlarining joylashuvi		
Kuchlanish	$U = U_1 + U_2 + U_3$	$U = U_1 = U_2 = U_3$
Tok kuchi	$I = I_1 = I_2 = I_3$	$I = I_1 + I_2 + I_3$

Photo source: [33] - https://www.electricaltechnology.org/wp-content/uploads/2020/05/Difference-Between-Series-and-Parallel-Circuit.png

FOYDALANILGAN MANBALAR:

1. https://kaiserscience.files.wordpress.com/2016/03/small-vs-large-electrical-current1.gif
2. https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcS4-nV0-C0OjNyzDtgR9ub-sgOMYdO16d0e6dvYPx7Vc97Or8_xJ7UUCc0aE929M7hwhZQ&usqp=CAU
3. https://1.bp.blogspot.com/-FokgDwMszuc/XbRy5vWcuSI/AAAAAAAAAKY/Ywgu8bXYNi0MDgbMYZjDv-vbhv6UZMaZACLcBGAsYHQ/s1600/resist3.gif
4. https://www.rfcafe.com/references/electrical/images2/resistivity.gif
5. Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., -2013. – 30 (905) p.
6. https://www.allaboutcircuits.com/uploads/thumbnails/conductance_thumbnail.jpg
7. https://www.shutterstock.com/image-vector/resistor-isolated-electrical-parts-vector-260nw-1562914033.jpg
8. https://i.ytimg.com/vi/sR_uPI08a9c/maxresdefault.jpg
9. https://www.nagwa.com/en/explainers/927152480586/
10. https://mammothmemory.net/images/user/base/Physics/Electricity/Ohms%20law/ohms-law.c1c09ec.jpg
11. https://static.wixstatic.com/media/4cbe06_fed4edf5660c483ba4081eb6709029a2~mv2.jpg/v1/fill/w_640,h_426,al_c,lg_1,q_80,enc_auto/4cbe06_fed4edf5660c483ba4081eb6709029a2~mv2.jpg
12. https://www.youtube.com/watch?v=Gc1wVdbVI0E
13. https://i.ytimg.com/vi/cgtSKaVTPmY/hqdefault.jpg
14. Fundamentals of Electric Circuits, Charles K. Alexander and Matthew N. O. Sadiku / 5th edition, the McGraw-Hill Companies, Inc., -2013. – p 32.
15. https://www.dummies.com/wp-content/uploads/489264.image0.jpg
16. https://www.dummies.com/wp-content/uploads/489267.image3.jpg
17. https://www.electrokit.com/uploads/productimage/40810/40810233.png
18. https://components101.com/sites/default/files/inline-images/Resistor-Symbols.png
19. https://www.ohmite.com/assets/images/buckets/TUM_1-updated.jpg
20. https://blogmedia.testbook.com/blog/wp-content/uploads/2022/10/parts-of-carbon-resistor-39aec770.png
21. https://static4.arrow.com/-/media/arrow/images/miscellaneous/h/how-to-read-resistor-color-codes.jpg
22. https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/dccircuits-dcp4.gif
23. https://www.circuitbasics.com/wp-content/uploads/2020/05/How-a-Potentiometer-Works-1024x655.png
24. ttps://makeabilitylab.github.io/physcomp/electronics/assets/videos/Potentiometer_Overview_ByJonFroehlich.mp4
25. https://makeabilitylab.github.io/physcomp/electronics/assets/images/SchematicSymbolsOfVariableResistors_ByJonFroehlich.png
26. https://probots.co.in/pub/media/catalog/product/cache/ca2cd736c0c15942c77daffc8cf27b66/1/k/1k_ohm_variable_resistor_potentiometer1-1000x1000.jpg
27. https://www.circuitbasics.com/wp-content/uploads/2020/05/Potentiometer-Voltage-Output-on-Arduino-Serial-Monitor-1024x848.jpg
28. https://img.freepik.com/premium-photo/closeup-printed-circuit-board-with-components-such-as-resistors-integrated-circuits_483511-3552.jpg
29. https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/dccircuits-dcp25.gif
30. https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/dccircuits-dcp4a.gif
31. https://www.electricaltechnology.org/wp-content/uploads/2013/12/How-to-Find-the-Number-of-Branches-in-an-Electric-Circuit.png
32. https://www.electricaltechnology.org/wp-content/uploads/2013/12/How-to-Determine-the-Number-of-Nodes-Loops-Branches-and-Meshes-in-a-Circuit-.png
33. https://www.electricaltechnology.org/wp-content/uploads/2020/05/Difference-Between-Series-and-Parallel-Circuit.png

E'TIBORINGIZ UCHUN RAHMAT!!!