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מצגות לימודיות להוראת מיקרו-מעבדים,אסמבלר,תקשורת,מערכות הפעלה.
שאול קובל
אלקטרוניקה בסיסית
חשמל זרם ישר - חוקי Ohm - Kirchoof - הדגמות
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בוקר טוב !!
נא לשמור על השקט!!
תודה
אוגוסט 2004
תכינו את דפי העזר וכלי כתיבה ורשמו הערות על פי הצורך
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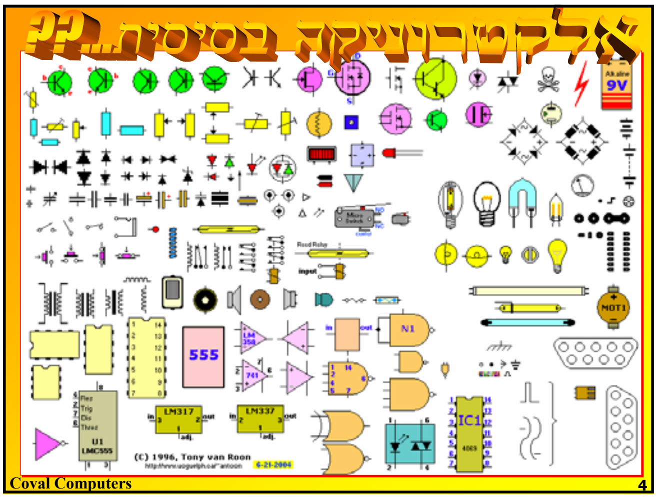
מטרות המודול
הקרת המרכבים הפנימיים של רשת עם נגדים
הקרת המרכבים של מקורות חשמל
דרך חישוב של מעגלים חשמליים


אלקטרוניקה בסיסית...??
555
LM317
LM337
IC1
(C) 1996, Tony van Roon
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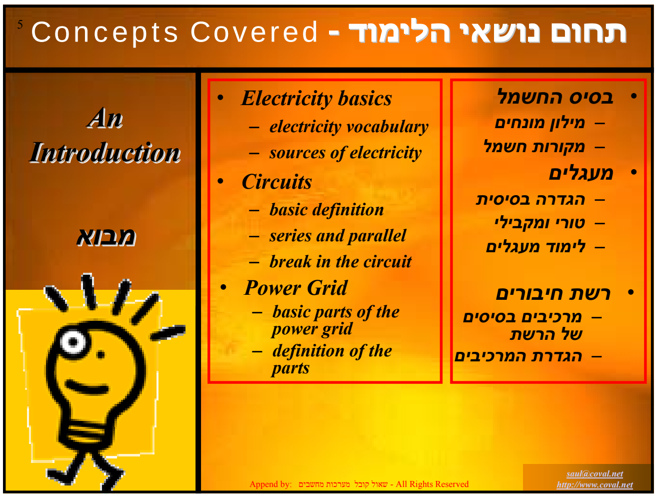
5
Concepts Covered - תחום נושאי הלימוד
An Introduction
מבוא
Electricity basics
electricity vocabulary
sources of electricity
Circuits
basic definition
series and parallel
break in the circuit
Power Grid
basic parts of the power grid
definition of the parts
בסיס החשמל
מילון מונחים
מקורות חשמל
מעגלים
הגדרה בסיסית
טורי ומקבילי
ליתוק מעגלים
רשת חיבורים
מרכבים בסיסיים של הרשת
הגדרת המרכבים
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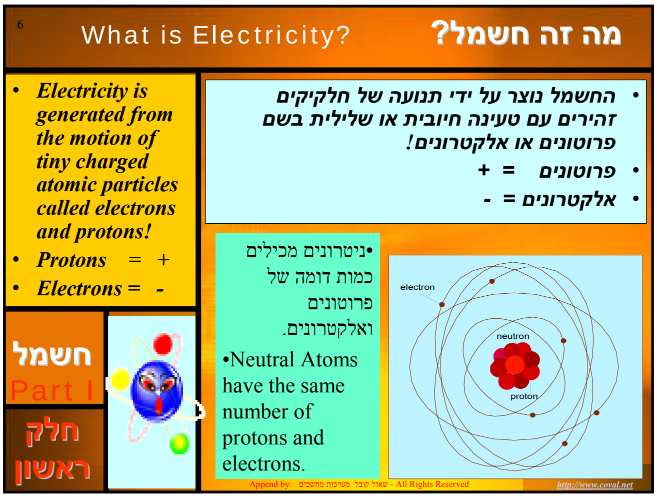
6
What is Electricity?
מה זה חשמל?
Electricity is generated from the motion of tiny charged atomic particles called electrons and protons!
Protons = +
Electrons = -
החשמל נוצר על ידי תנועה של חלקיקים זהירים עם טעינה חיובית או שלילית בשם פרוטונים או אלקטרונים!
פרוטונים = +
אלקטרונים = -
•ניטרונים מכילים כמות דומה של פרוטונים ואלקטרונים.
•Neutral Atoms have the same number of protons and electrons.
electron
neutron
proton
חשמל
Part I
חלק ראשון
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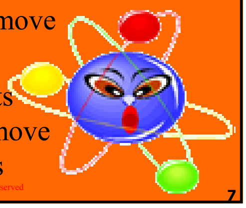
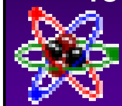
- כאמור, האטומים מורכבים מניטרונים ואלקטרונים. לאלקטרונים טעינה שלילית ויכולים לנוע בחופשיות.
- כדוגמה, בזמן שפשוף בין שני דברים כלשהם יכול לגרום למעבר אלקטרונים מאחד על השני. תנועה זו של אלקטרונים ניקרא **חשמל!**

- Atoms are made up of protons, neutrons, and electrons. The electrons have a negative charge and can move freely.
- For example, rubbing two objects together can cause electrons to move from one object to another. This abundant of electrons is called



The Elements - המרכיבים היסודיים

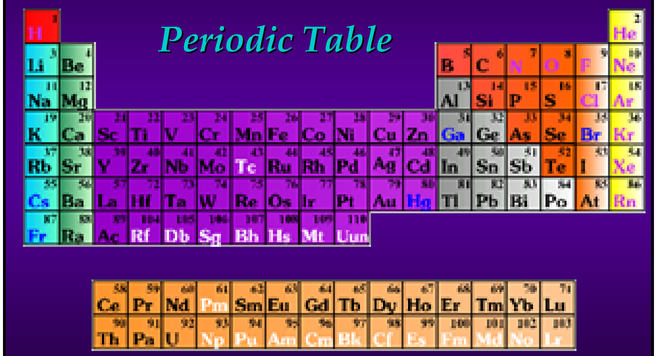


- כל דבר שמסביבנו, חי או לא חי, הוא הרכב של מרכיבי יסוד.
- עד היום זוהו 109 מרכיבי יסוד.
- האטומים הם במרכיבים הקטנים ביותר של מרכיבי היסוד.

- All matter, however complex, living or nonliving, is some combination of the elements.
- Currently, 109 elements have been identified.
- Atoms are the smallest form of the elements.

טבלת מרכיבי היסודות

Periodic Table



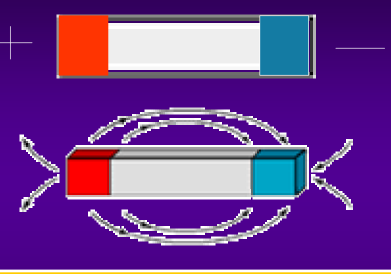
Electrical Charges - טעינת חשמל

- היחידה לטעינת חשמל היא: <u>coulomb</u>.
  - לטעינת של קולומב אחד דרושים מעל 6 billion billion (6.25×10^{18} protons) .
- טעינת החשמל תמיד נשמר. ניתן להעביר הטעינה ממקום אחד לשני, אבל לא ניתן להשמידה.

- The unit of electric charge is the <u>coulomb</u>.
  - Over 6 billion billion (6.25×10^{18} protons) to have a charge of one coulomb!
- Electric charge is conserved. Charge can be transferred from one place to another, but it is not destroyed.

Electric Charges & Magnets — טעינת חשמל ומגנטים

- Simple Bar Magnet



- Results

קוטביות שווה "נמשך" — קוטביות שווה "נדחה"

Opposite ends "Attract" — Like ends "Repel"

What is the difference in conductors and insulators?

- Conductors allow electricity to flow through very easily. Metals and humans are both conductors. Electrons in this material can flow with relative ease
- Insulators (dielectric) do not allow electricity to flow through easily. Rubber, glass, and plastic are all good insulators. Electrons in this material require very high voltage

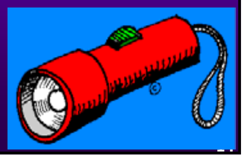
מה הוא ההבדל בין מוליכים לבין מבודדים ?

- מוליכים מאפשרים לחשמל לזרום בקלות. מתכות ובני אדם הם מוליכים טובים. בחומרים ההם האלקטרונים נעים בחופשיות יחסית.
- מבודדים לא מאפשרים זרימת החשמל לזרום בקלות. מבודדים טובים הם גומי, זכוכית ופלסטיק. בחומרים ההם האלקטרונים זקוקים במתחים גדולים יחסית עבור תנועתם.

Types of Circuits - סוגי מעגלים

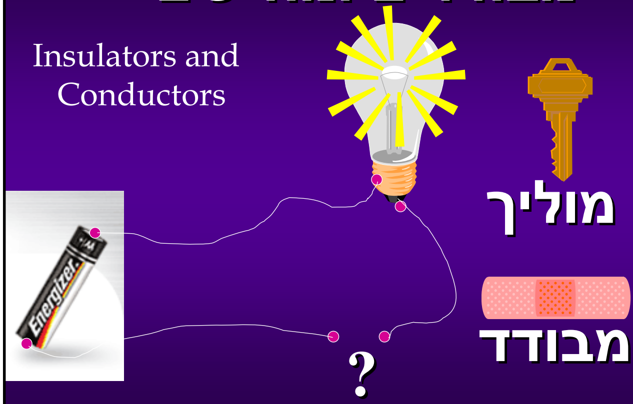
- קיימים שני סוגי מעגלים הנקראים מעגל סגור ומעגל פתוח.
- כדי שהחשמל תזרום המעגל חייב להיות **סגור!**
- בדרך כלל מפסיק מבקר את פתיחת וסגירת המעגל. כדוגמה: פנס יד.

- The two types of circuits are called open circuit and closed circuit.
- In order for electric current to flow, the circuit must be CLOSED!
- A switch controls the opening and closing of a circuit. Example: flashlight



מבודדים ומוליכים

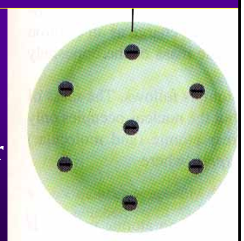
Insulators and Conductors



Thompson's model - המודל של טומפסון

- האלקטרונים הם תלויים כמו נוצות בתוך מבנה דומה לפודינג, שטעון עם מטען חיובי.
- מודל זה נדחה לאחר ניסויים של הפרדת החלקיקים.

- Electrons are suspended like plums in a mixture of positively charged pudding.
- This model was rejected after experimentation with diffraction of particles.



Protons and Neutrons - פרוטונים וניטרונים

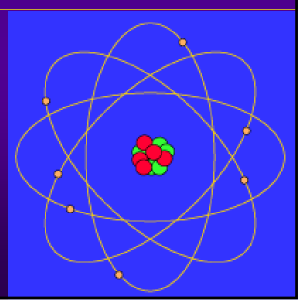
- מספר אטומי = כמות הפרוטונים בתוך אטום.
  - כל האטומים עם אותו מספר אטומי הם בעלי אותם תחונות כימיקלים.
- איזוטופ = אטומים עם אותו מספר אטומי אבל עם מספר שונה של ניטרונים.
- מאסה אטומי או מספר מאסה = כמות החלקיקים הנכללים במרכז האטום (פרוטונים ועוד ניטרונים).

- Atomic number = the number of protons in an atom
  - All atoms with the same atomic number have the same chemical properties.
- Isotope = atoms with the same atomic number but differing numbers of neutrons.
- Atomic mass or Mass number = the total number of particles contained in a nucleus, (protons plus neutrons).

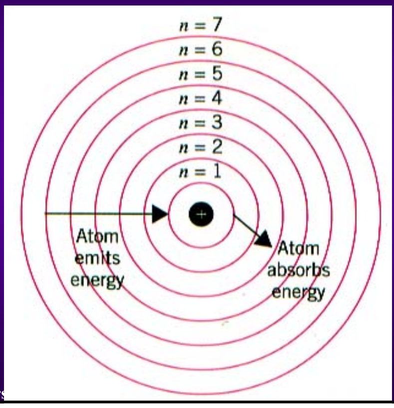
Bohr's model of the atom - המודל של בוהר

- בשנת 1911, Niels Bohr היציע מודל חדש בו האלקטרונים נעים סביב המרכז במעגלים בשם "קונכיות אנרגיה".
- אלקטרונים במעגלים שונים כוללים כמויות שונות של אנרגיה.

- In 1911 Niels Bohr proposed a model in which electrons orbited the nucleus in circular orbits called energy shells.
- Electrons in different orbits contain different amounts of energy.



Bohr's model - המודל של בוהר



Superconductivity - מוליכות יתירה

- In certain materials as temperature is lowered to a critical temperature, R = 0Ω i.e. zero resistance to current flow.
- Zero resistance means no I^2R heating losses
- applications:
  - transmission lines
  - electrical energy storage
  - magnetic levitation

Superconductivity - מוליכות יתירה

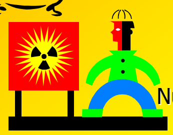
- Until recently, very low temperatures were required, < 20° K
- In 1987, discovery of superconductivity in yttrium-barium-copper oxide at >100 ° K resulted in liquid nitrogen being used as a coolant.
- Goal is a room temperature superconductor.

מקורות ליצירת חשמל

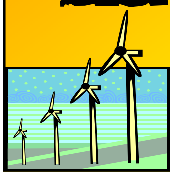
Types of Sources used to make Electricity

- Thermal - תרמי

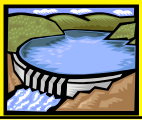
- Geothermal - גיאו-תרמי



- Solar - שמש
- Nuclear - גרעיני
- Hydroelectric - כוח המים



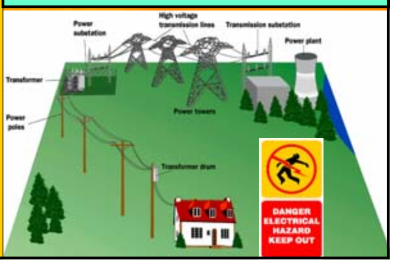
- Wind - רוח



How do we get Electricity? - איך מקבלים את החשמל?

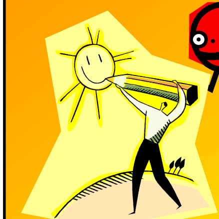
- *Energy from one of the sources is converted by machines at the power plant to Electricity and then put onto the Electric Power Grid*
- *Electric Power Grid*
  - *Power Plants*
  - *Transmission Lines*
  - *Substations*
  - *Power Lines*
  - *Transformers*
  - *Electrical Wiring and Circuit Box*

אנרגיה מאחד המקורות עובר עיבוד על ידי מכשירים מיוחדים בתחנת החשמל ומועבר לרשת החשמל ודרכו עד הצרכנים.



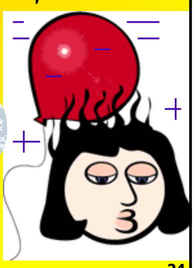
ניסוי ביתי ליצירת חשמל (מסוג סטטי)

- Static Electricity

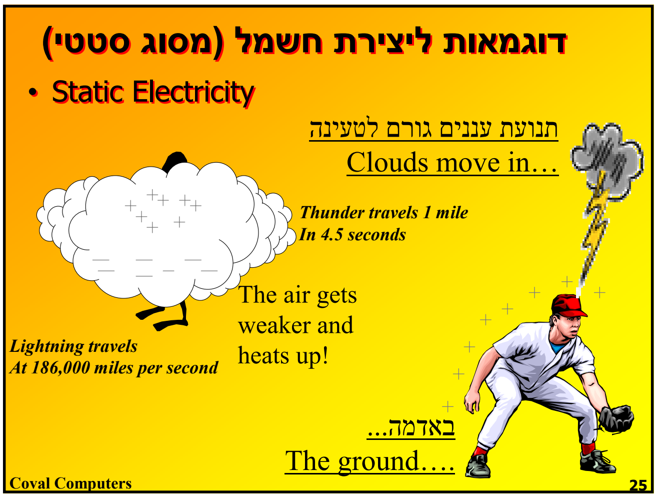


לאחר שפשוף הבלון או הסודר, הם יהיו **בעלי מטען חשמלי!**

Like charges attract



After rubbing both of these items, they now have a CHARGE!


דוגמאות ליצירת חשמל (מוסג סטטי)
• Static Electricity
תנועת עננים גורם לטעינה
Clouds move in…
Thunder travels 1 mile
In 4.5 seconds
The air gets weaker and heats up!
Lightning travels
At 186,000 miles per second
באדמה…
The ground….
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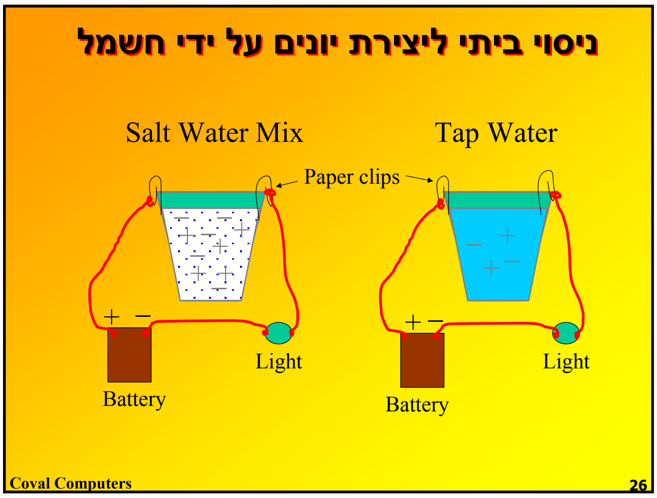
ניסוי ביתי ליצירת יונים על ידי חשמל
Salt Water Mix
Tap Water
Paper clips
Light
Battery
Light
Battery
Coval Computers
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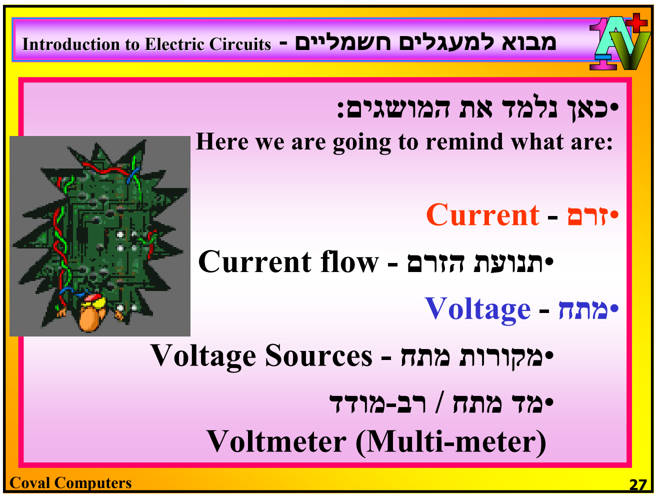
Introduction to Electric Circuits - מבוא למעגלים חשמליים
•כאן נלמד את המושגים:
Here we are going to remind what are:
•זרם - Current
•תנועת הזרם - Current flow
•מתח - Voltage
•מקורות מתח - Voltage Sources
•מד מתח / רב-מודד
Voltmeter (Multi-meter)
Coval Computers
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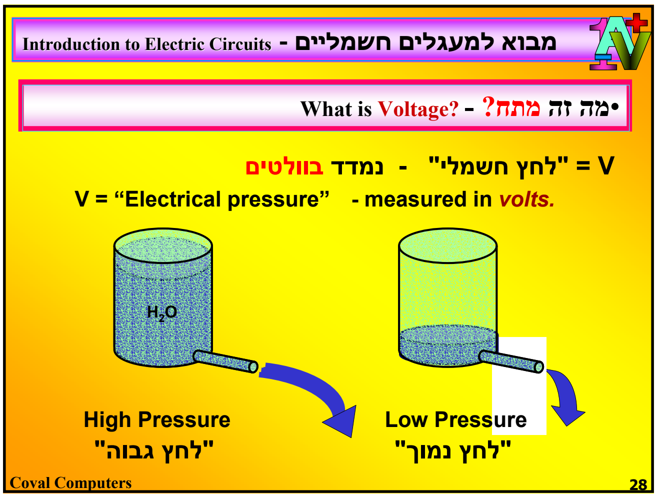
Introduction to Electric Circuits - מבוא למעגלים חשמליים
•מה זה מתח? - What is Voltage?
V = "לחץ חשמלי" - נמדד בוולטים
V = "Electrical pressure" - measured in volts.
H2O
High Pressure
"לחץ גבוא"
Low Pressure
"לחץ נמוך"
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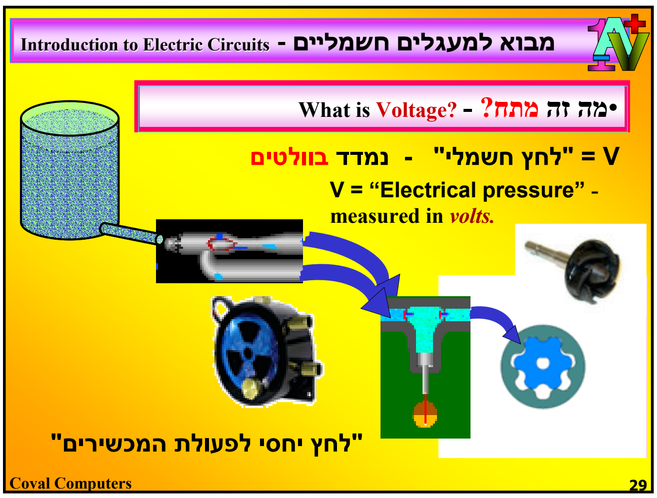
Introduction to Electric Circuits - מבוא למעגלים חשמליים
•מה זה מתח? - What is Voltage?
V = "לחץ חשמלי" - נמדד בוולטים
V = "Electrical pressure" -
measured in volts.
"לחץ יחסי לפעולת המכשירים"
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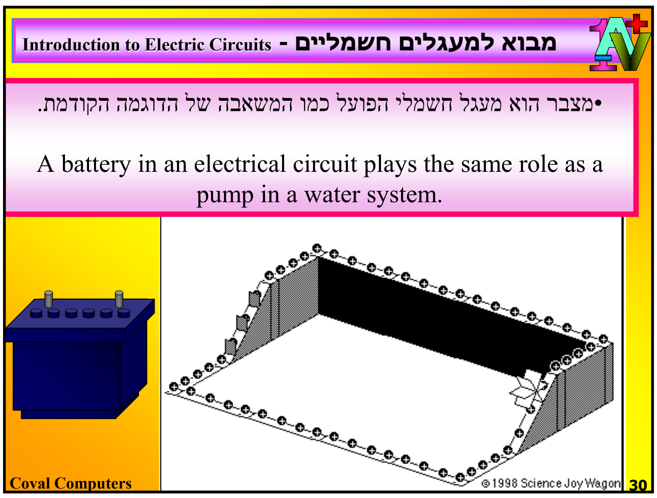
Introduction to Electric Circuits - מבוא למעגלים חשמליים
•מצבר הוא מעגל חשמלי הפועל כמו המשאבה של הדוגמה הקודמת.
A battery in an electrical circuit plays the same role as a pump in a water system.
©1998 Science Joy Wagon
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Introduction to Electric Circuits - מבוא למעגלים חשמליים
What Produces Voltage? - מה מייצר מתח?•
V = "Electrical pressure" - "לחץ חשמלי"
סוללות
Battery
9 V
1.5 V
Lab Power Supply
ספק
כוח
מעבדות
תא שמש
Solar Cell
תחנת חשמל
Electric
Power
Plant
13,500 V
תא עצב
Nerve Cell
וולטים בודדים
A few Volts
מילי-וולטים בודדים
A few millivolts when
activated by a synapse
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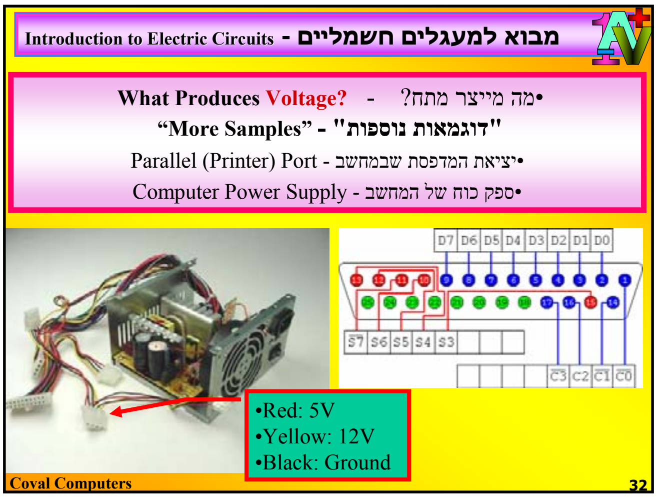
Introduction to Electric Circuits - מבוא למעגלים חשמליים
What Produces Voltage? - מה מייצר מתח?•
"More Samples" - "דוגמאות נוספות"
Parallel (Printer) Port - יציאת המדפסת שבמחשב•
Computer Power Supply - ספק כוח של המחשב•
D7 D6 D5 D4 D3 D2 D1 D0
S7 S6 S5 S4 S3
C3 C2 C1 C0
•Red: 5V
•Yellow: 12V
•Black: Ground
Coval Computers
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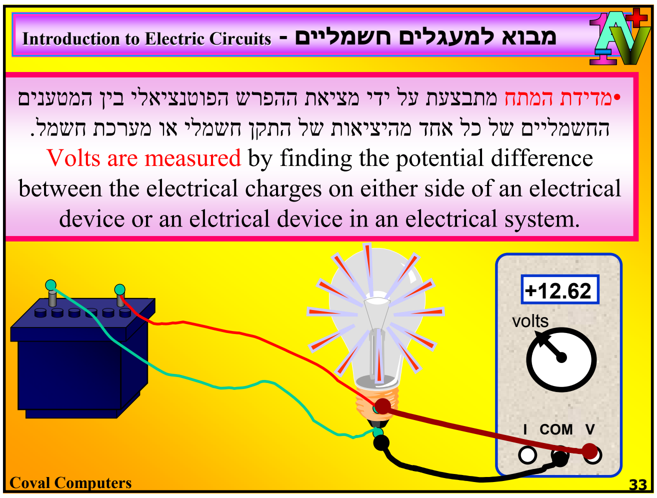
Introduction to Electric Circuits - מבוא למעגלים חשמליים
•מדידת המתח מתבצעת על ידי מציאת ההפרש הפוטנציאלי בין המטענים החשמליים של כל אחד מהיציאות של התקן חשמלי או מערכת חשמל.
Volts are measured by finding the potential difference between the electrical charges on either side of an electrical device or an elctrical device in an electrical system.
+12.62
volts
I COM V
Coval Computers
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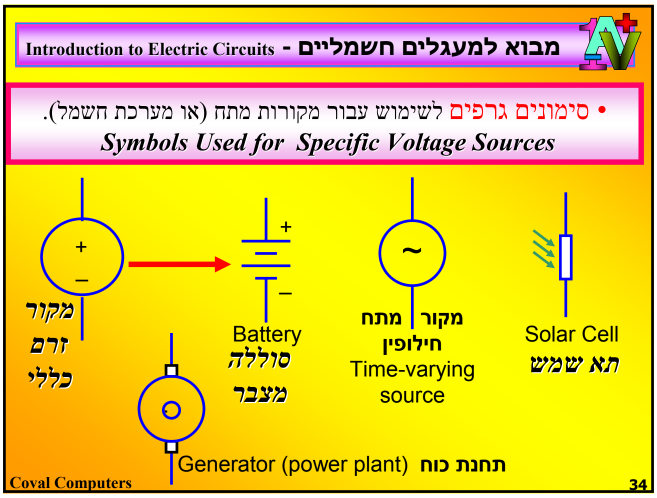
Introduction to Electric Circuits - מבוא למעגלים חשמליים
• סימונים גרפים לשימוש עבור מקורות מתח (או מערכת חשמל).
Symbols Used for Specific Voltage Sources
מקור
זרם
כללי
Battery
סוללה
מצבר
מקור מתח
חילופין
Time-varying
source
Solar Cell
תא שמש
Generator (power plant) תחנת כוח
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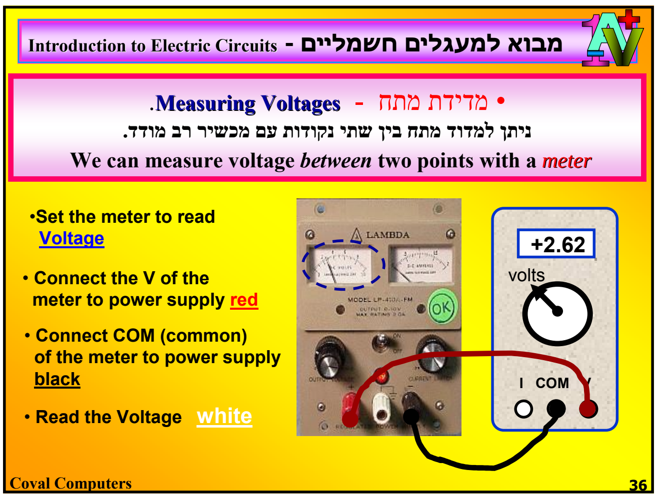
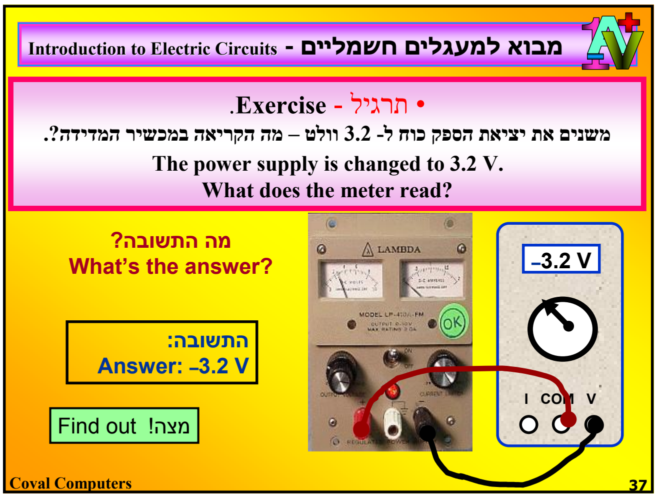
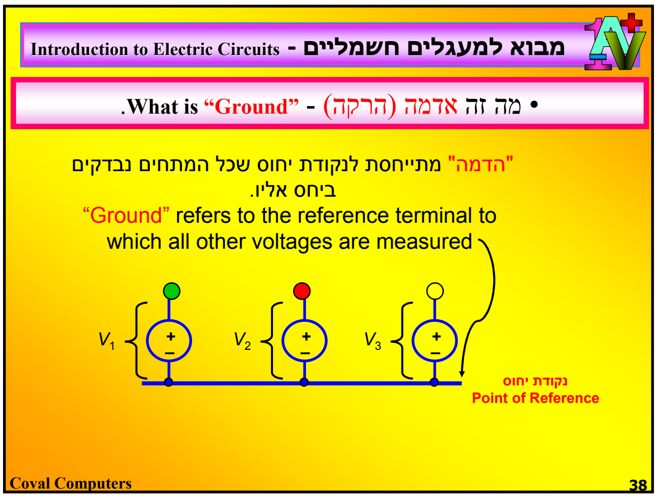
Introduction to Electric Circuits - מבוא למעגלים חשמליים
• מקור מתח טיפוסי למעבדות מחקר ולימוד
לשימוש עבור ניסוים בחשמל.
A Typical Voltage Source Voltage Sources
Lab Power Supply
This supply goes up
to 10 V
The voltage is adjustable
via this knob
The red (+) and black (-)
terminals emulate the two
ends of a battery.
The white terminal is
connected to earth ground
via the third prong of the
power cord
Remember: A voltage is measured between two points
Coval Computers
35


Introduction to Electric Circuits - מבוא למעגלים חשמליים
• מדידת מתח - Measuring Voltages.
ניתן למדוד מתח בין שתי נקודות עם מכשיר רב מודד.
We can measure voltage between two points with a meter
•Set the meter to read
Voltage
• Connect the V of the
meter to power supply red
• Connect COM (common)
of the meter to power supply
black
• Read the Voltage white
+2.62
volts
I COM
Coval Computers
36


Introduction to Electric Circuits - מבוא למעגלים חשמליים
• תרגיל - Exercise.
משנים את יציאת הספק כוח ל- 3.2 וולט – מה הקריאה במכשיר המדידה?.
The power supply is changed to 3.2 V.
What does the meter read?
מה התשובה?
What's the answer?
התשובה:
Answer: –3.2 V
Find out מצא!
LAMBDA
OK
–3.2 V
I COM V
Coval Computers
37


Introduction to Electric Circuits - מבוא למעגלים חשמליים
• מה זה אדמה (הרקה) - What is "Ground".
"הדמה" מתייחס לנקודת יחוס שכל המתחים נבדקים ביחס אליו.
"Ground" refers to the reference terminal to which all other voltages are measured
V_1
V_2
V_3
נקודת יחוס
Point of Reference
Coval Computers
38


Introduction to Electric Circuits - מבוא למעגלים חשמליים
• כדור הארץ זה נקודת יחוס (אדמה, הרקה) מאוד גדול.
The earth is really just one big ground node.
Most people choose the earth as the reference ground when a connection to it is available.
רוב האנשים בוחרים את האדמה כנקודת יחוס, כאשר ניתן לבצע חיבור מסוג זה.
V_2
A ground connection to earth is often made via the third prong of a power cord.
בדרך כלל, חיבור לאדמה מתבצע דרך חיבור של תקע מיוחד.
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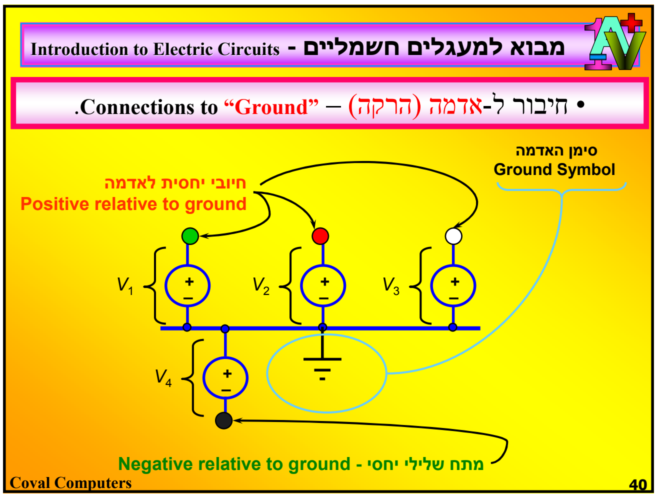
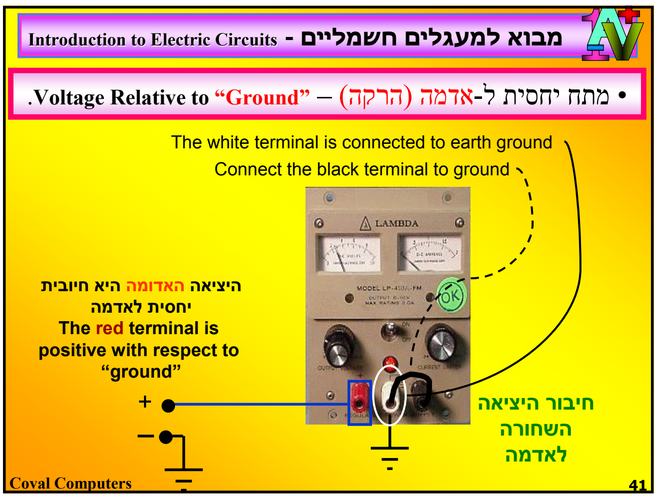
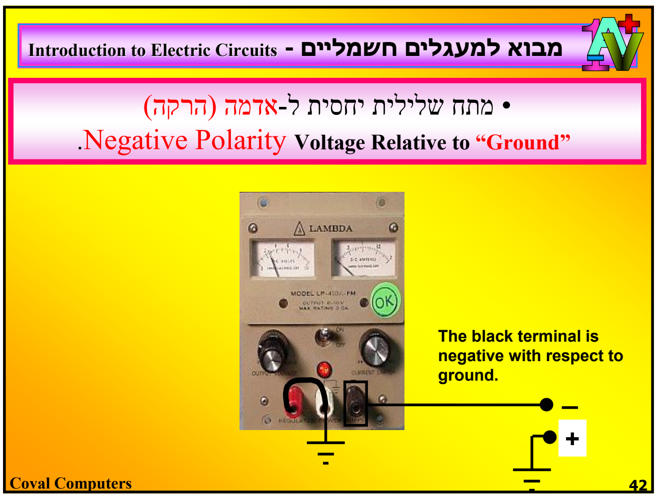
39


Introduction to Electric Circuits - מבוא למעגלים חשמליים
• חיבור ל-אדמה (הרקה) – Connections to "Ground".
סימן האדמה
Ground Symbol
חיובי יחסית לאדמה
Positive relative to ground
V_1
V_2
V_3
V_4
Negative relative to ground - מתח שלילי יחסי
Coval Computers
40


Introduction to Electric Circuits - מבוא למעגלים חשמליים
• מתח יחסית ל-אדמה (הרקה) – Voltage Relative to "Ground".
The white terminal is connected to earth ground
Connect the black terminal to ground
היציאה האדומה היא חיובית יחסית לאדמה
The red terminal is positive with respect to "ground"
חיבור היציאה השחורה לאדמה
LAMBDA
OK
+
–
Coval Computers
41


Introduction to Electric Circuits - מבוא למעגלים חשמליים
• מתח שלילית יחסית ל-אדמה (הרקה)
Negative Polarity Voltage Relative to "Ground".
LAMBDA
OK
The black terminal is negative with respect to ground.
–
+
Coval Computers
42

Introduction to Electric Circuits - מבוא למעגלים חשמליים

• מה זה זרם? – What is Current?

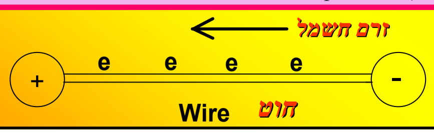
זרם הוא כמות של מטען חשמלי (קולומב) העובר דרך נקודה מיוחדת של מוליך בפרק זמן של שנייה אחד.

Current is the amount of electric charge (coulombs) flowing past a specific point in a conductor over an interval of one second.

• 1 ampere = 1 coulomb/second

• אלקטרון נע מנקודה של פוטנציאל נמוך לכיוון של פוטנציאל גבוה.

Electron flow is from a lower potential (voltage) to a higher potential (voltage).



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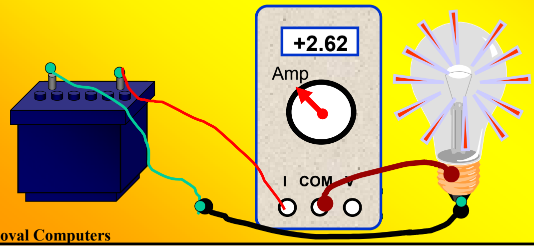
Introduction to Electric Circuits - מבוא למעגלים חשמליים

• A = "זרם חשמלי" - נמדד באמפרים (Ampers)

מדידת הזרם מתבצעת על ידי חיבור מד זרם בטור בין מקור המתח לבין הצרכן.

Amps are measured by placing an ammeter in the flow of current and measuring that current.



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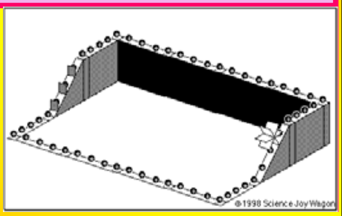
Introduction to Electric Circuits - מבוא למעגלים חשמליים

• מה זה זרם? – What is Current?

עקב סיבות היסטוריות, הזרם נחשב כזרם מנקודות החיובית לנקודת השלילית של מעגל חשמלי.

For historical reasons, current is **conventionally** thought to flow from the positive to the negative potential in a circuit.

- Electron flow is from (-) to (+) *(flow of electrons)*
- **Conventional flow** is from (+) to (-) *(hole flow)*



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Introduction to Electric Circuits - מבוא למעגלים חשמליים

Electrical Current – זרם החשמל

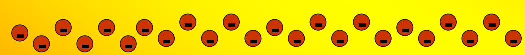
Sign Convention for Current Flow - כללים של זרימת זרם החשמל

• לאלקטרונים טעינה שלילית

Electrons carry negative charge

• הזרימה החיובית היא בכיוון הפוך

Positive current flow is in opposite direction



← **electron motion**

positive current direction →

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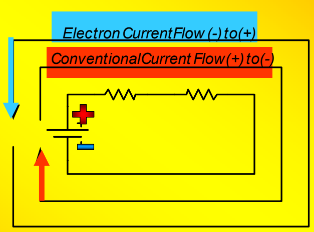
Introduction to Electric Circuits - מבוא למעגלים חשמליים

Electrical Current – זרם החשמל - סיכום!

Convention for Current Flow - כללים של זרימת זרם החשמל

- Electron flow is from (-) to (+) *(flow of electrons)*
- **Conventional flow** is from (+) to (-) *(hole flow)*



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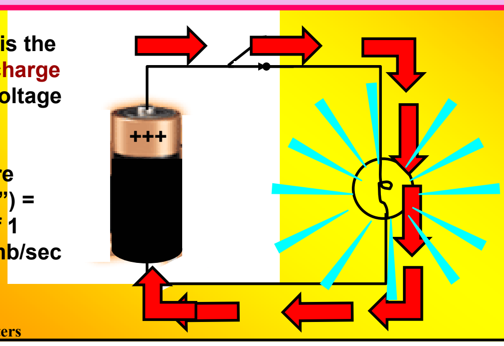
Introduction to Electric Circuits - מבוא למעגלים חשמליים

Electrical Current – זרם החשמל - סיכום!

זרם החשמל – זרימת מטענים מתוך מקור מתח (בדוגמה: סוללה)

- **Current is the flow of charge from a voltage source.**
- **1 Ampere (“Amp”) = Flow of 1 Coulomb/sec**



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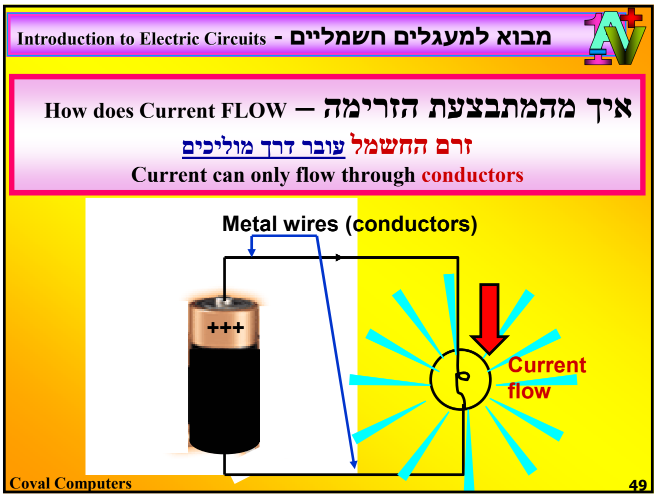
Introduction to Electric Circuits - מבוא למעגלים חשמליים
How does Current FLOW – איך מהמתבצעת הזרימה
זרם החשמל עובר דרך מוליכים
Current can only flow through conductors
Metal wires (conductors)
+++
Current flow
Coval Computers
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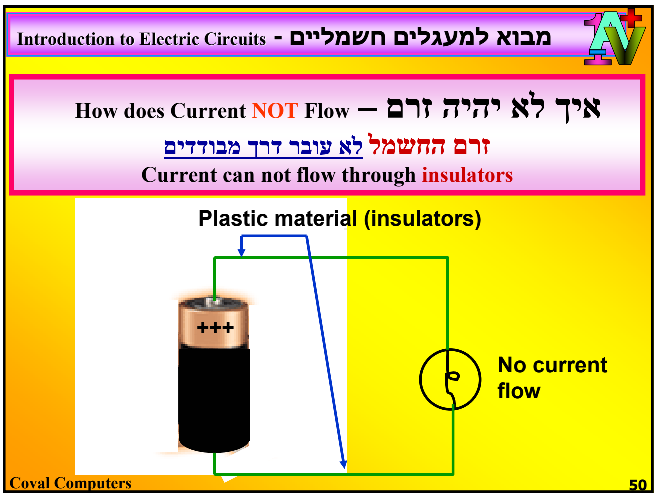
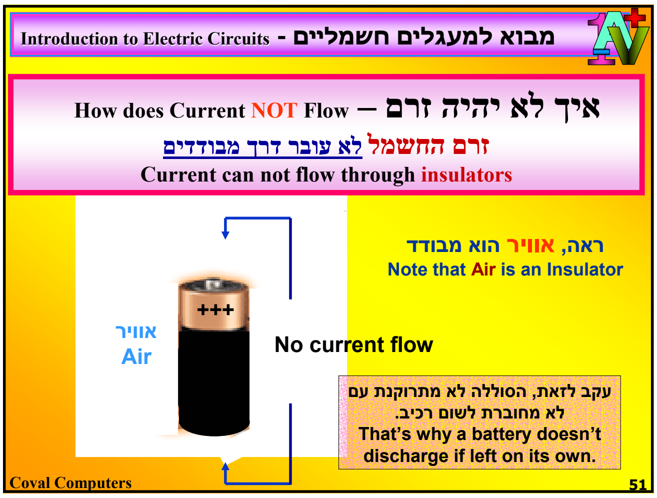

Introduction to Electric Circuits - מבוא למעגלים חשמליים
How does Current NOT Flow – איך לא יהיה זרם
זרם החשמל לא עובר דרך מבודדים
Current can not flow through insulators
Plastic material (insulators)
+++
No current flow
Coval Computers
50


Introduction to Electric Circuits - מבוא למעגלים חשמליים
How does Current NOT Flow – איך לא יהיה זרם
זרם החשמל לא עובר דרך מבודדים
Current can not flow through insulators
ראה, אוויר הוא מבודד
Note that Air is an Insulator
אוויר
Air
+++
No current flow
עקב לזאת, הסוללה לא מתרוקנת עם
לא מחוברת לשום רכיב.
That's why a battery doesn't discharge if left on its own.
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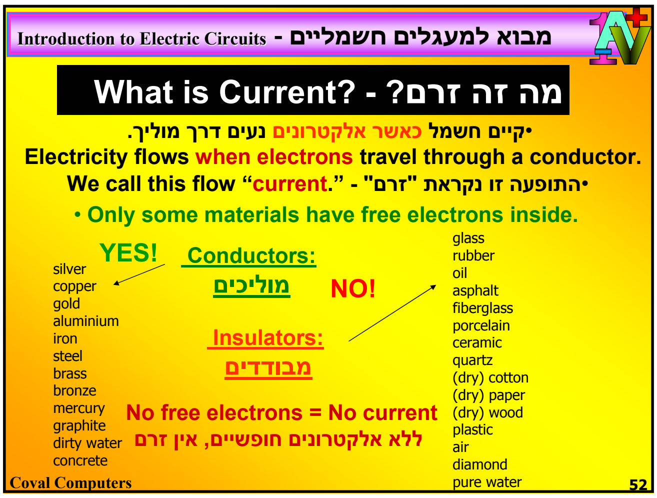
Introduction to Electric Circuits - מבוא למעגלים חשמליים
What is Current? - מה זה זרם?
•קיים חשמל כאשר אלקטרונים נעים דרך מוליך.
Electricity flows when electrons travel through a conductor.
We call this flow "current." - •התופעה זו נקראת "זרם"
• Only some materials have free electrons inside.
YES!
Conductors:
מוליכים
NO!
Insulators:
מבודדים
silver
copper
gold
aluminium
iron
steel
brass
bronze
mercury
graphite
dirty water
concrete
glass
rubber
oil
asphalt
fiberglass
porcelain
ceramic
quartz
(dry) cotton
(dry) paper
(dry) wood
plastic
air
diamond
pure water
No free electrons = No current
ללא אלקטרונים חופשיים, אין זרם
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Introduction to Electric Circuits - מבוא למעגלים חשמליים
Electricity – החשמל - תרגיל!
מה מודדים בכל אחד מהמעגלים שבהמשך ?
12 volts
12 volts
Coval Computers
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Introduction to Electric Circuits - מבוא למעגלים חשמליים
יחס בין מתח לבין זרם
Relationship Between Voltage and Current
Direct relationship - •יחס ישיר
•אם ההפרש הפוטנציאלי (או מתח) גדל, אז זרם החשמל גדל
As electrical potential difference (or voltage) increases, electrical current increases.
•אם אמתח יורד , אז הזרם יורד.
.As voltage decreases, current decreases
בשני המקרים התנגדות הצרכן נשרת קבועה.
Resistance held constant .
Coval Computers
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Resistors (Resistance) – נגדים (התנגדות)

•התנגדות = הניגוד לזרמת אלקטרונים דרך חומר.
Resistance = opposition to the flow of electrons through a material.

Defined with the following formula :מוגדר דרך הנוסחה

$$R = \rho \; l / A = [\Omega]$$

- ρ = התנגדות החומר - resistivity of material.
- l = אורך החומר – length.
- A = שטח חתך של החומר - cross sectional area.

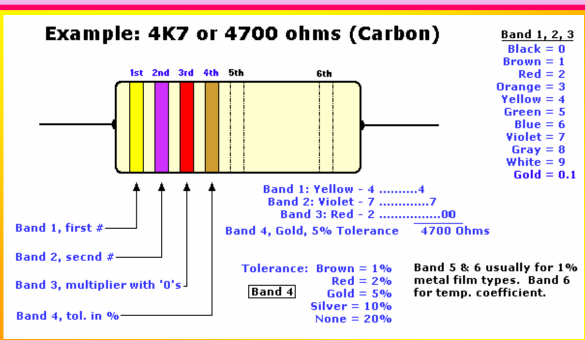
Resistors (Resistance) – נגדים (התנגדות)

Can be rated by… - • ניתן להגדרה על פי...

- התנגדות - Resistance (Ohms, Ω)
- אחוז דיוק -Tolerance (% of nominal value)
- הספק אפשרי - Power Rating (Watts)
- קבועים – Fixed

משתנים – Variable

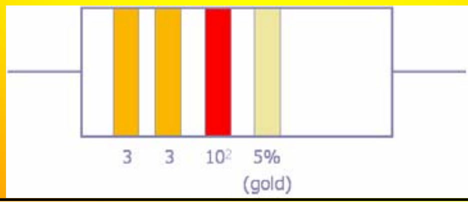
Color CODE – צופן הצבעים



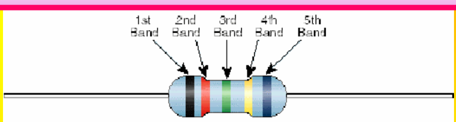
דוגמת חישוב בצופן הצבעים

- 1^{st} band: orange - כתום= 3
- 2^{nd} band: orange - כתום= 3
- 3^{rd} band: red - אדום= 2 (i.e. 10^2)
- 4^{th} band: gold - זהב= 5%

33×10^2
$= 3300\ \Omega$
$= 3.3\ k\Omega$



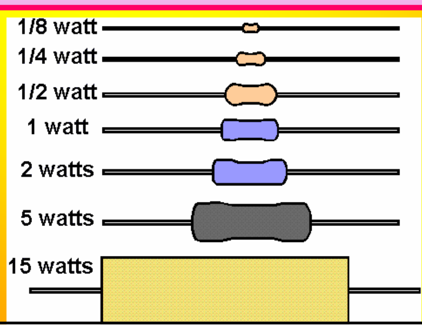
צופן הצבעים עם 5 פסים



Color	1st Band (1st figure)	2nd Band (2nd figure)	3rd Band (3rd figure)	4th Band (multiplier)	5th Band (tolerance)
Black	0	0	0	10^0	
Brown	1	1	1	10^1	±1%
Red	2	2	2	10^2	
Orange	3	3	3	10^3	
Yellow	4	4	4	10^4	
Green	5	5	5	10^5	±.5%
Blue	6	6	6	10^6	±.25%
Violet	7	7	7	10^7	±.1%
Gray	8	8	8	10^8	
White	9	9	9	10^9	
Gold				10^{-1}	

הגדרות על פי הספק הנגד

Resistors – Typical Power Ratings

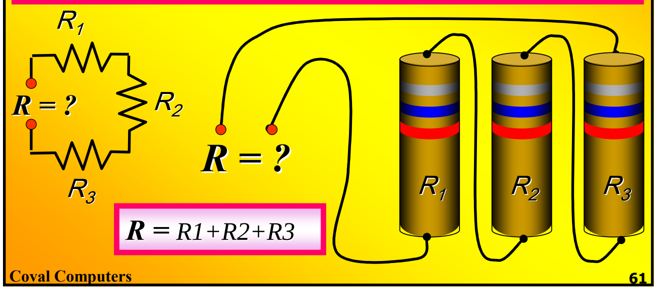


Introduction to Electric Circuits - מבוא למעגלים חשמליים

Series Resistors - חיבור נגדים בטור

ההתנגדות הכוללת שווה לסכום ההתנגדויות.

The equivalent resistance is equal to the sum of the resistors.



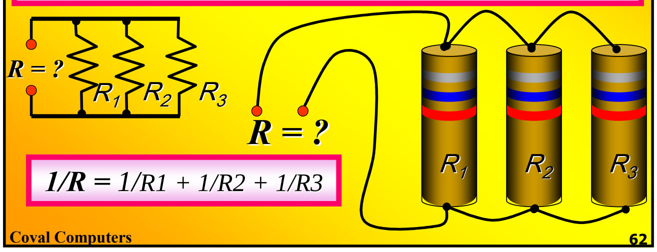
R = R1+R2+R3

Introduction to Electric Circuits - מבוא למעגלים חשמליים

Parallel Resistors - חיבור נגדים במקביל

היפוך ההתנגדות הכוללת שווה לסכום ההיפוכים של ההתנגדויות.

The reciprocal of the equivalent resistance of a set of parallel resistors is equal to the sum of the reciprocals of the resistances.



1/R = 1/R1 + 1/R2 + 1/R3

Introduction to Electric Circuits - מבוא למעגלים חשמליים

Property of Resistance - תכונות הנגדים

Resistivities of some basic materials- התנגדות של מספר חומרים בסיסים

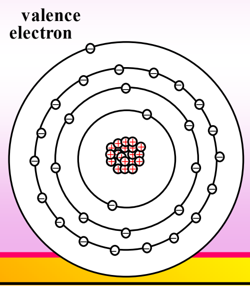
Material	Resistivity (ohm meters)	Common Use
•silver	1.6x10-8	conductor
•copper	1.7x10-8	conductor
•aluminum	2.8x10-8	conductor
•gold	2.5x10-8	conductor
•carbon	4.1x10-5	semiconductor
•germanium	47x10-2	semiconductor
•silicon	6.4x102	semiconductor
•paper	1x1010	insulator
•mica	5x1011	insulator
•glass	1x1012	insulator
•teflon	3x1012	insulator

Introduction to Electric Circuits - מבוא למעגלים חשמליים

Property of Resistance - תכונות הנגדים

למה מספר מוליכים הם טובים מאחרים?

Why are some materials better conductors than others? - Consider copper.

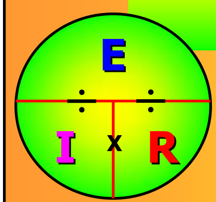


אטום של נחושת

Copper Atom

DC: Ohms Law - חוק אוהם

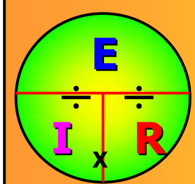
OHMS LAW



חוק אוהם

DC: Ohms Law - חוק אוהם

Introduction - מבוא



מי שהגדיר לראשונה את היחס בין מתח, זרם והתנגדות היה הגרמני סימון אוהם.

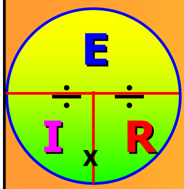
Georg Simon Ohm a German Physicist, Defined the law that dictates the relationship between Voltage, Current and Resistance.

Voltage

DC: Ohms Law - חוק אוהם

מתח: כוח תנועה של חשמל זה הפרש בפוטנציאל בין שתי נקודות **(+)** ו- **(-)**. דבר זה גורם לאלקטרונים לנוע או לזרום דרך מוליך.

Voltage: Electromotive Force, EMF, is a Difference in Potential { or force } between two points + & -. That causes electrons to move or flow in a conductor.



Symbol: E :סימון

Unit of measure: Volts or V: יחידה מדידה

EMF: *Is the electrical work done by a device per unit charge done to maintain a potential.* $\mathcal{E} = dW/dq$ - *Unit of* $[\mathcal{E}]$ = *Joule/ Coulomb = volt*

Current

DC: Ohms Law - חוק אוהם

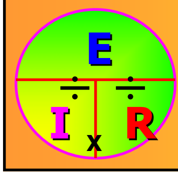
זרם: תנועת אלקטרונים מהנקודה השלילית ביותר לנקודה החיובית ביותר של המעגל.

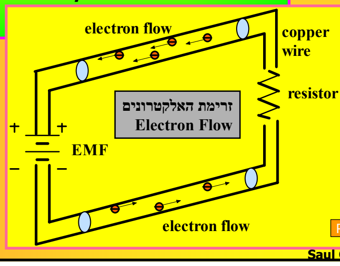
CURRENT: Is the MOVEMENT OF ELECTRONS From the most Negative, to the most Positive point in the circuit.

Symbol: I :סימון

Measured in units of: **- יחידות לחישובים/מדידות**

Amperes, {Amps} A



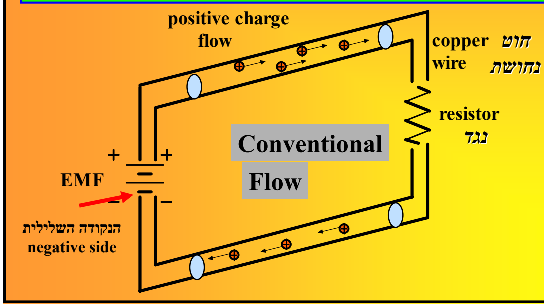


Resistance

DC: Ohms Law - חוק אוהם

על פי הסכמה, כיוון הזרם הוא לכיוון הנקודה השלילית של מעגל החשמלי.

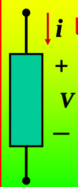
Conventional current flow assumes positive charges move toward the negative side of the circuit EMF.



DC: Ohms Law - חוק אוהם

התנגדות: ניגוד לזרם אלקטרונים

הנגד מבקרת לזרימת האלקטרונים



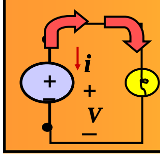
Resistance: Is the opposition to the flow of current.

Resistance controls the flow of current.

Symbol: R :הסימון

Unit of Measure - יחידות לחישובים/מדידה

Ohms, Ω [KΩ]



The resistance of the resistor is a function of temperature. When the resistor is submerged it is much colder than before and the resistance drops, increasing the current flows through it

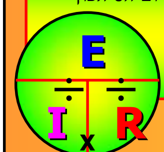
Calculate E

DC: Ohms Law - חוק אוהם

•הזרם שזורם בתוך מעגל הוא ביחס ישיר להפרש הפוטנציאלי וביחס הפוך להתנגדות.

•התנגדות זו תחונה של סוג וחומר דרכו עובר הזרם.

•יחידת המדידה של התנגדות היא אוהם [ohm (Ω)].



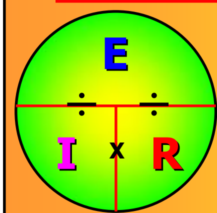
•The current flowing through a circuit is directly proportional to the potential difference and inversely proportional to the resistance.

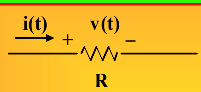
•Resistance is a property of the type and size of the material through which the current is flowing. (Compare to R-value in heat transfer)

•The unit of resistance is the ohm (Ω).

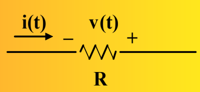
DC: Ohms Law - חוק אוהם

•הזרם שזורם בתוך מעגל הוא ביחס ישיר להפרש הפוטנציאלי וביחס הפוך להתנגדות.



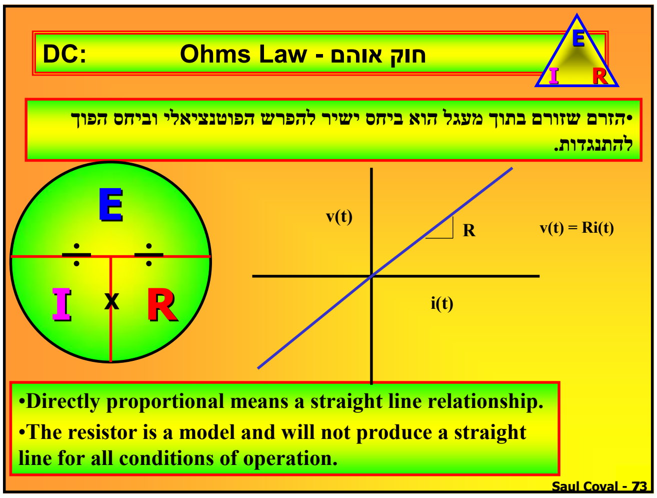


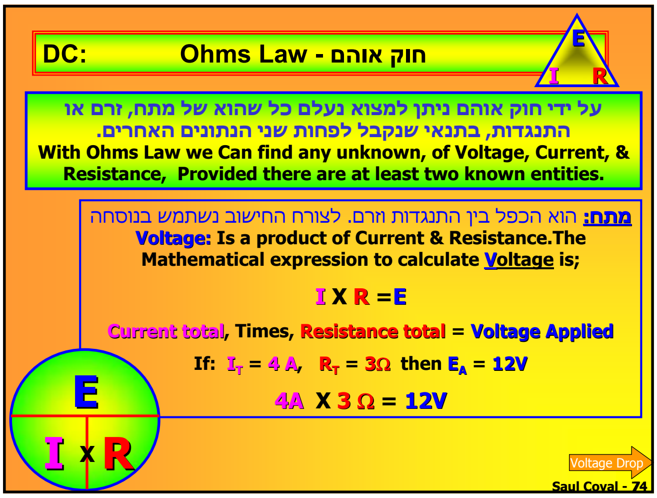
v(t) = Ri(t)

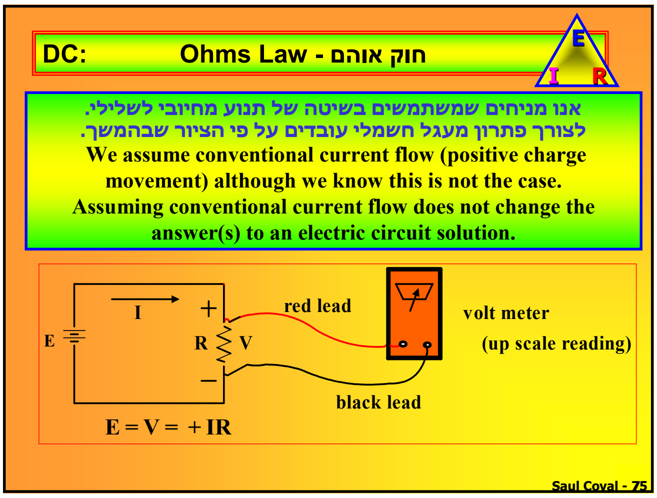


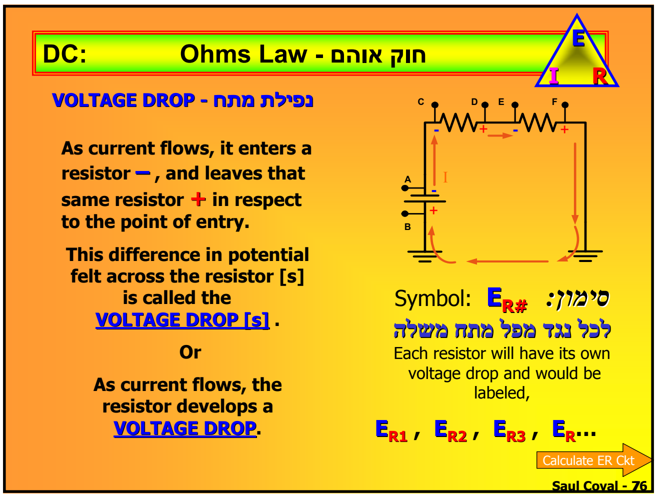
v(t) = − Ri(t)

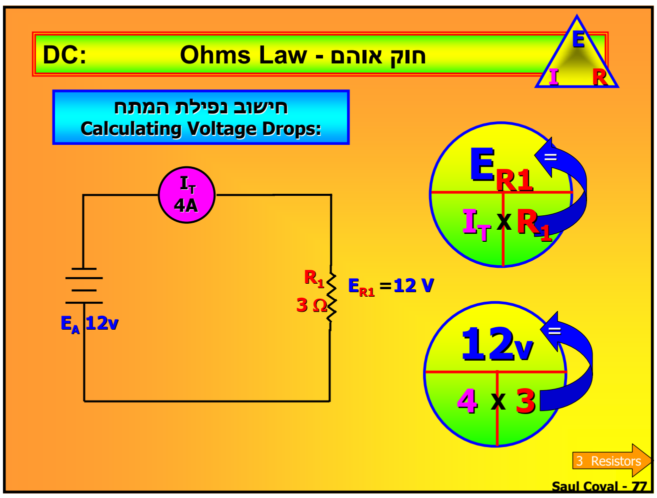
•The voltage across a resistor is directly proportional to the current moving through the resistor.

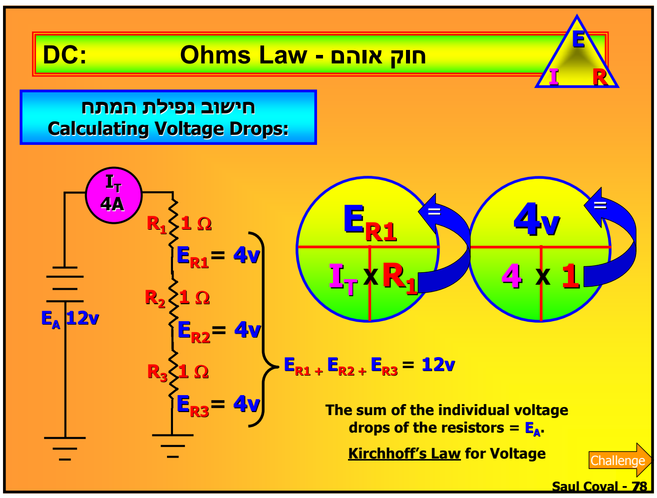

DC: Ohms Law - חוק אוהם
E
I R
•הזרם שזורם בתוך מעגל הוא ביחס ישיר להפרש הפוטנציאלי וביחס הפוך להתנגדות.
E
I x R
v(t)
R
v(t) = Ri(t)
i(t)
•Directly proportional means a straight line relationship.
•The resistor is a model and will not produce a straight line for all conditions of operation.
Saul Coval - 73

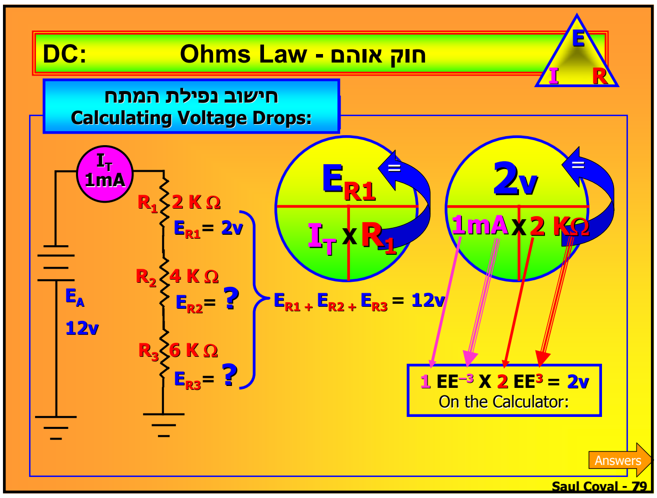

DC: Ohms Law - חוק אוהם
E
I R
על ידי חוק אוהם ניתן למצוא נעלם כל שהוא של מתח, זרם או התנגדות, בתנאי שנקבל לפחות שני הנתונים האחרים.
With Ohms Law we Can find any unknown, of Voltage, Current, & Resistance, Provided there are at least two known entities.
מתח: הוא הכפל בין התנגדות וזרם. לצורך החישוב נשתמש בנוסחה
Voltage: Is a product of Current & Resistance.The Mathematical expression to calculate Voltage is;
I X R = E
Current total, Times, Resistance total = Voltage Applied
If: I_T = 4 A, R_T = 3Ω then E_A = 12V
4A X 3 Ω = 12V
E
I x R
Voltage Drop
Saul Coval - 74

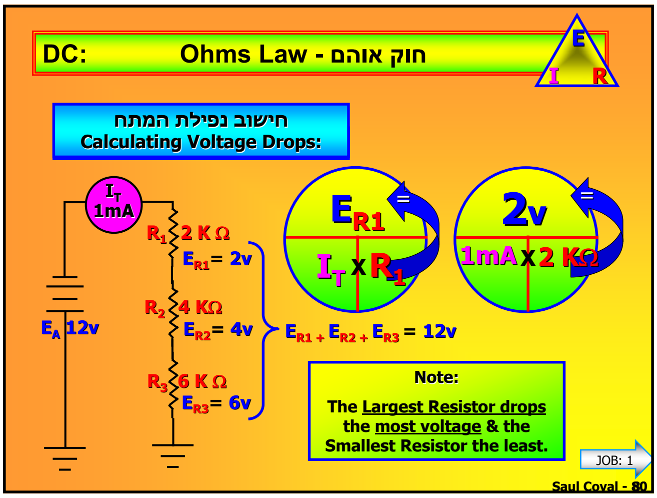

DC: Ohms Law - חוק אוהם
E
I R
אנו מניחים שמשתמשים בשיטה של תנוע מחיובי לשלילי.
לצורך פתרון מעגל חשמלי עובדים על פי הציור שבהמשך.
We assume conventional current flow (positive charge movement) although we know this is not the case.
Assuming conventional current flow does not change the answer(s) to an electric circuit solution.
I
+
red lead
volt meter
(up scale reading)
E
R
V
−
black lead
E = V = + IR
Saul Coval - 75

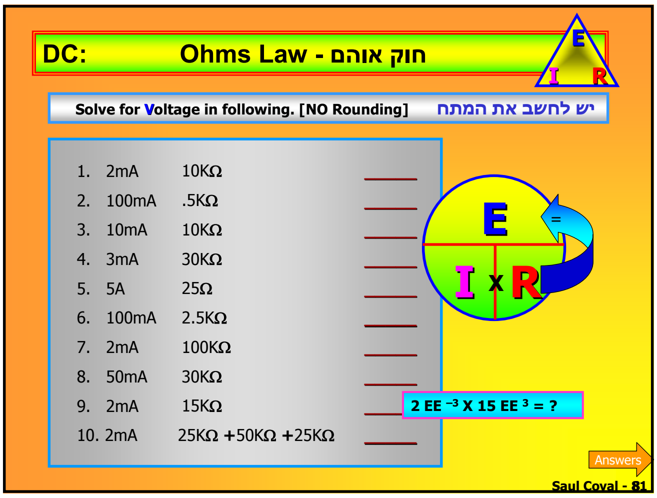

DC: Ohms Law - חוק אוהם
E
I R
VOLTAGE DROP - נפילת מתח
As current flows, it enters a resistor −, and leaves that same resistor + in respect to the point of entry.
This difference in potential felt across the resistor [s] is called the VOLTAGE DROP [s] .
Or
As current flows, the resistor develops a VOLTAGE DROP.
C D E F
A
B
Symbol: $E_{R\#}$ סימון:
לכל נגד מפל מתח משלה
Each resistor will have its own voltage drop and would be labeled,
E_{R1} , E_{R2} , E_{R3} , E_R…
Calculate ER Ckt
Saul Coval - 76

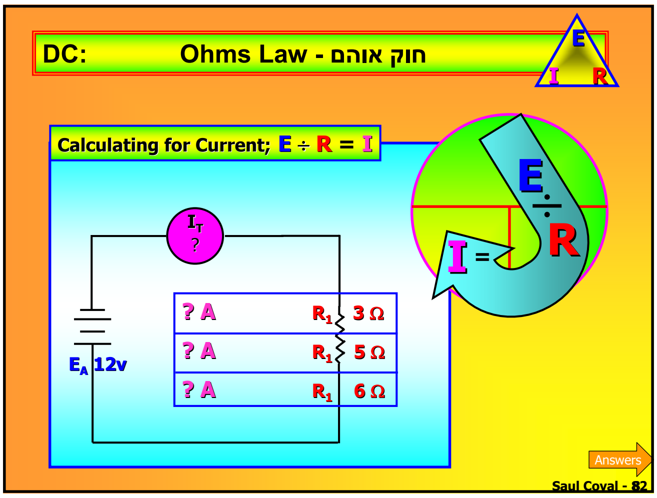

DC: Ohms Law - חוק אוהם
E
I R
חישוב נפילת המתח
Calculating Voltage Drops:
I_T
4A
E_A 12v
R_1
3 Ω
E_{R1} =12 V
E_{R1}
I_T x R_1
=
12v
4 x 3
=
3 Resistors
Saul Coval - 77

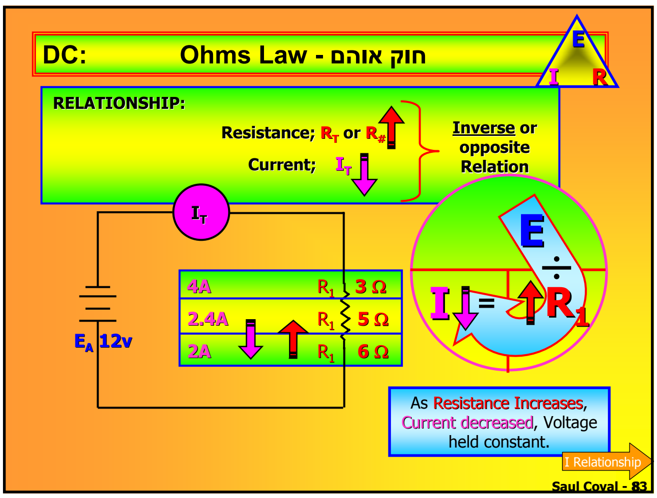

DC: Ohms Law - חוק אוהם
E
I R
חישוב נפילת המתח
Calculating Voltage Drops:
I_T
4A
E_A 12v
R_1 1 Ω
E_{R1} = 4v
R_2 1 Ω
E_{R2} = 4v
R_3 1 Ω
E_{R3} = 4v
E_{R1} + E_{R2} + E_{R3} = 12v
E_{R1}
I_T x R_1
4v
4 x 1
=
The sum of the individual voltage drops of the resistors = E_A.
Kirchhoff's Law for Voltage
Challenge
Saul Coval - 78

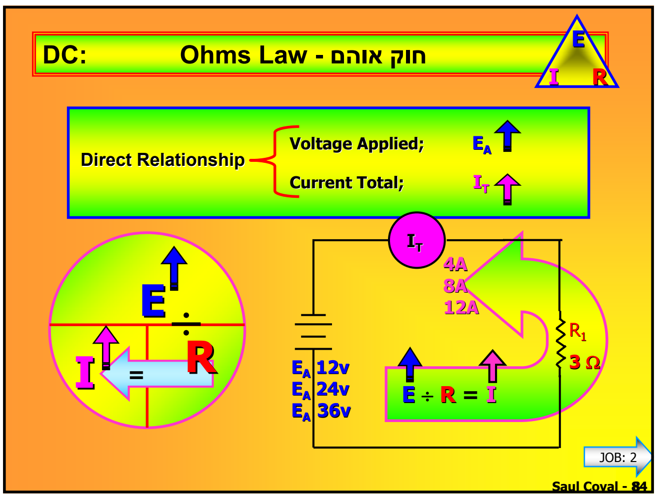

DC: Ohms Law - חוק אוהם
חישוב נפילת המתח
Calculating Voltage Drops:
I_T 1mA
R_1 2 K Ω
E_{R1} = 2v
R_2 4 K Ω
E_{R2} = ?
R_3 6 K Ω
E_{R3} = ?
E_A 12v
$E_{R1} + E_{R2} + E_{R3}$ = 12v
E_{R1}
I_T x R_1
2v
1mA x 2 KΩ
1 EE^{-3} X 2 EE^{3} = 2v
On the Calculator:
Answers
Saul Coval - 79


DC: Ohms Law - חוק אוהם
חישוב נפילת המתח
Calculating Voltage Drops:
I_T 1mA
R_1 2 K Ω
E_{R1} = 2v
R_2 4 KΩ
E_{R2} = 4v
R_3 6 K Ω
E_{R3} = 6v
E_A 12v
$E_{R1} + E_{R2} + E_{R3}$ = 12v
E_{R1}
I_T x R_1
2v
1mA x 2 KΩ
Note:
The Largest Resistor drops the most voltage & the Smallest Resistor the least.
JOB: 1
Saul Coval - 80


DC: Ohms Law - חוק אוהם
Solve for Voltage in following. [NO Rounding] יש לחשב את המתח
1. 2mA 10KΩ
2. 100mA .5KΩ
3. 10mA 10KΩ
4. 3mA 30KΩ
5. 5A 25Ω
6. 100mA 2.5KΩ
7. 2mA 100KΩ
8. 50mA 30KΩ
9. 2mA 15KΩ
10. 2mA 25KΩ +50KΩ +25KΩ
E
I x R
2 EE $^{-3}$ X 15 EE ^{3} = ?
Answers
Saul Coval - 81


DC: Ohms Law - חוק אוהם
Calculating for Current; E ÷ R = I
I_T ?
E_A 12v
? A R_1 3 Ω
? A R_1 5 Ω
? A R_1 6 Ω
E ÷ R
I =
Answers
Saul Coval - 82


DC: Ohms Law - חוק אוהם
RELATIONSHIP:
Resistance; R_T or $R_\#$
Current; I_T
Inverse or opposite Relation
I_T
E_A 12v
4A R_1 3 Ω
2.4A R_1 5 Ω
2A R_1 6 Ω
E ÷ R_1
I =
As Resistance Increases, Current decreased, Voltage held constant.
I Relationship
Saul Coval - 83


DC: Ohms Law - חוק אוהם
Direct Relationship
Voltage Applied; E_A
Current Total; I_T
E ÷ R
I =
I_T
4A
8A
12A
E_A 12v
E_A 24v
E_A 36v
R_1
3 Ω
E ÷ R = I
JOB: 2
Saul Coval - 84

DC: Ohms Law - חוק אוהם

JOB 2: Solve for Current in following. [NO Rounding]

1.	100v	25KΩ	____
2.	60v	120KΩ	____
3.	10v	60KΩ	____
4.	10v	5KΩ	____
5.	1000v	250KΩ	____
6.	24v	12KΩ	____
7.	48v	8KΩ	____
8.	20v	100Ω	____ or ____
9.	45v	15KΩ	____
10.	36v	6KΩ	____

E ÷ I = R

Note: If there is KΩ in the Resistance, Current will be in mA

* 45 ÷ 15 EE³ =.003A =?

Answers

Saul Coval - 85

DC: Ohms Law - חוק אוהם

Resistance, is the opposition to the flow of current.

Resistance controls the flow of current.

Symbol: R

Unit of Measure: Ohms, Ω

E ÷ I = R

2 Major Types of Resistors:

1. Fixed Value:
2. Variable:

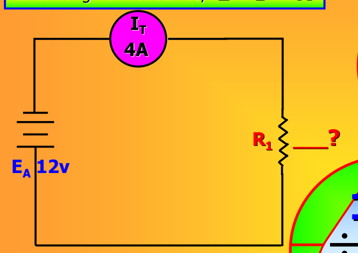
Common symbol | Potentiometer | Rheostat

Calculating R

Saul Coval - 86

DC: Ohms Law - חוק אוהם

Calculating For Resistance; **E ÷ I = R**



E ÷ I = R

12v ÷ 4A = 3Ω

JOB: 3

Saul Coval - 87

DC: Ohms Law - חוק אוהם

JOB 3: Solve for Resistance in following. [NO Rounding]

1.	60v	5mA	____
2.	250v	100mA	____
3.	500v	2mA	____
4.	300v	3mA	____
5.	25v	1mA	____
6.	50v	20mA	____
7.	250v	50mA	____
8.	250v	25mA	____
9.	500v	10mA	____
10.	1000v	2.5mA	____

E ÷ I = R

Note: If there is mA of Current, Resistance will be in KΩ.

*500 ÷ 10 EE-3 = 50,000. = ?

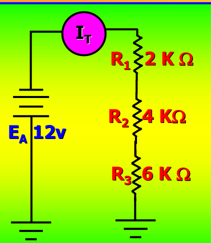
Answers

Saul Coval - 88

DC: Ohms Law - חוק אוהם

Ohms Law is used to find the operating parameters of a circuit [Ckt].

E ÷ I x R



I_T x R_T = | E_A = ___v
$R_1 + R_2 + R_3$ = | R_T = ___Ω
EA ÷ R_T = | I_T = ___ mA
I_T x R_1 = | E_{R1}= ___v
I_T x R_2 = | E_{R2}= ___v
I_T x R_3 = | E_{R3}= ___v

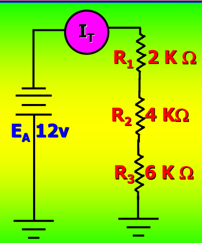
Answers

Saul Coval - 89

DC: Ohms Law - חוק אוהם

Ohms Law is used to find the operating parameters of a circuit [Ckt].

E ÷ I x R



I_T x R_T = | E_A = 12v
$R_1 + R_2 + R_3$ = | R_T = 12K Ω
EA ÷ R_T = | I_T = 1 mA
I_T x R_1 = | E_{R1}= 2v
I_T x R_2 = | E_{R2}= 4v
I_T x R_3 = | E_{R3}= 6v

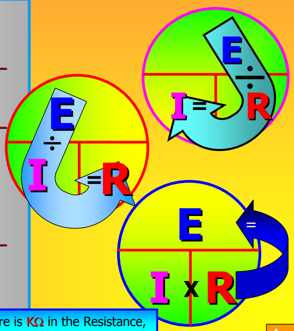
JOB: 4

Saul Coval - 90

DC: Ohms Law - חוק אוהם

JOB 4: Solve for **required values** in following. [NO Rounding]

1.	____	100K Ω	30v
2.	5mA	75K Ω	____
3.	20A		115v
4.	50mA	8K Ω	____
5.	3mA	____	48v
6.	____	60K Ω	10v
7.	4mA	____	88v
8.	7mA	910K Ω	____
9.	12.5mA	____	150v
10.	____	800K Ω	64v



Note: If there is KΩ in the Resistance, Current will be in mA. & Vise Versa

Answers

DC: Ohms Law - חוק אוהם

Lesson Test:

Standard: **10 Questions W/in 20 Minutes. 70% Minimum Accuracy. 80% for EOD.**

Reference: **Official OMEMS Training Aids.**

M = X 10^6	EE 6	
K = X 10^3	EE 3	
Whole Unit = X 10^0		
m = X 10^{-3}	EE	3
µ = X 10^{-6}	EE	6

Physics 2220

Chapter 28 Direct Current Circuits

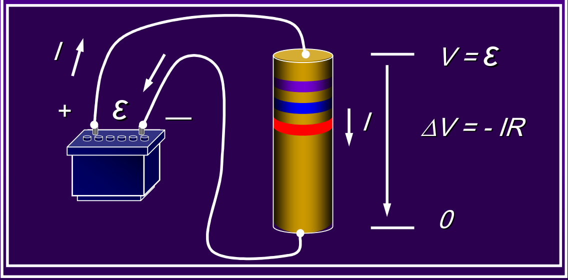
1′ Lecture:

- *The potential drops across a resistor in the direction of the current flow. $\Delta V = -IR$*
- *The potential across an emf source is $\mathcal{E}$ in the direction of current flow.*
- *In a circuit the charge and current in the capacitor are*
  $q(t) = Q(1 - e^{-t/RC})$
  $I(t) = -(Q/RC)\, e^{-t/RC}$

Physics 2220

Chapter 28 Direct Current Circuits

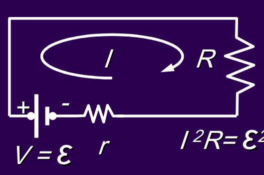
Resistors in Circuits



Physics 2220

Chapter 28 Direct Current Circuits

Resistors in Circuits



$\Delta V = -IR$

$\mathcal{E} - IR - Ir = 0$

$I = \mathcal{E}/(R+r)$

$P = I\mathcal{E} = I^2R + I^2r$

$I^2R = \mathcal{E}^2[\,1/(R+r) - r/(R+r)^2]$

Physics 2220

Chapter 28 Direct Current Circuits

Maximum Power delivered by Battery:

$I^2R = \mathcal{E}^2[\,1/(R+r) - r/(R+r)^2]$

$d(I^2R)/dr = \mathcal{E}^2[\,-/(R+r)^2 + 2r/(R+r)^3] = 0$

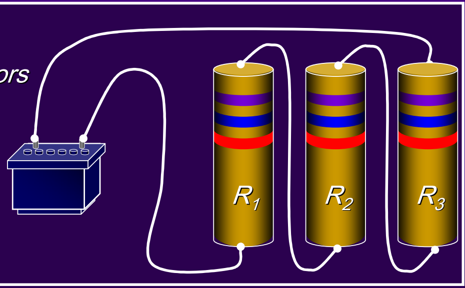
$-(R+r) + 2r = 0$

$r = R$ for maximum power delivered

$(IR)_{max} = \mathcal{E}^2[\,1/2R - R/(2R)^2] = 3/4\, \mathcal{E}^2/R$

Physics 2220
Chapter 28 Direct Current Circuits

Resistors in Circuits



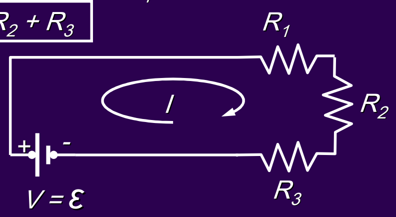
Physics 2220
Chapter 28 Direct Current Circuits

Resistors in Circuits

$\mathcal{E} = IR_1 + IR_2 + IR_3 = I\,R_{eq}$

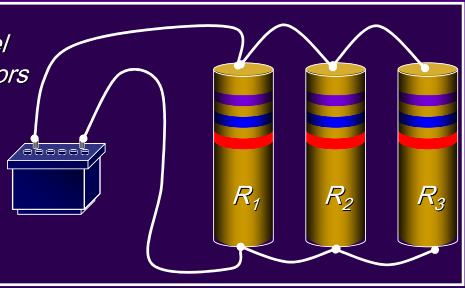
$R_{eq} = R_1 + R_2 + R_3$

Series Resistors



Physics 2220
Chapter 28 Direct Current Circuits

Resistors in Circuits



Physics 2220
Chapter 28 Direct Current Circuits

Resistors in Circuits

$\mathcal{E}/R_{eq} = \mathcal{E}/R_1 + \mathcal{E}/R_2 + \mathcal{E}/R_3$

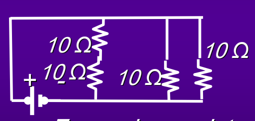
$1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3$

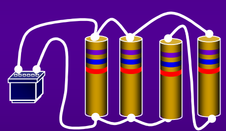
Parallel Resistors

Physics 2220
Chapter 28 Direct Current Circuits

Practice and Application:

What is the resistance of the following circuit if all resistors are 10 Ω?





For series resistors

$R_{eq} = 10\,\Omega + 10\,\Omega = 20\,\Omega$

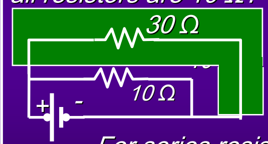
Then for Parallel Resistors

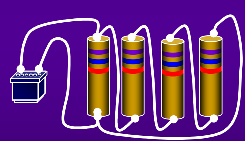
$R_{||} = [1/10\,\Omega + 1/10\,\Omega + 1/20\ \Omega]^{-1} = \boxed{4\,\Omega}$

Physics 2220
Chapter 28 Direct Current Circuits

Practice and Application:

What is the resistance of the following circuit if all resistors are 10 Ω?





For series resistors

$R_s = 10\,\Omega + 10\,\Omega + 10\,\Omega = 30\,\Omega$

Then Parallel Resistors

$R_{||} = 1/[1/30\,\Omega + 1/10\,\Omega] = \boxed{7.5\,\Omega}$

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Kirchhoff's Rules:

Junction Rule:
$\Sigma I_{in} = \Sigma I_{out}$

Loop Rule:
$\Sigma_{Loop} \; \Delta V = 0$

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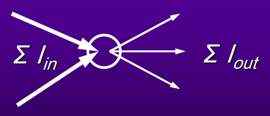
Kirchhoff's Rules:

Junction Rule—

$\Sigma I_{in} = \Sigma I_{out}$



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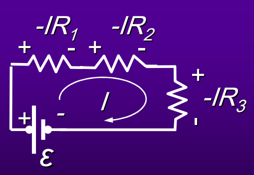
Kirchhoff's Rules:

Loop Rule—

$\Sigma_{Loop} \; \Delta V = 0$



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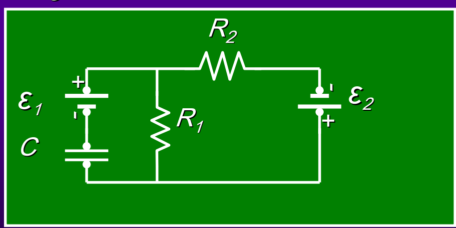
Practice and Application:

What are the currents and potentials in the following circuit?



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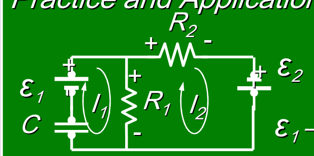
Practice and Application:



Loop 1:

$\varepsilon_1 - (I_1 - I_2) R_1 - Q/C = 0$

Loop 2: $-(I_2 - I_1) R_1 - I_2 R_2 - \varepsilon_2 = 0$

Solve for I_1 and I_2:

$I_2 = (\varepsilon_1 - \varepsilon_2 - Q/C)/R_2$

$I_1 = (\varepsilon_1 - Q/C)(1/R_2 + 1/R_1) - \varepsilon_2 / R_2$

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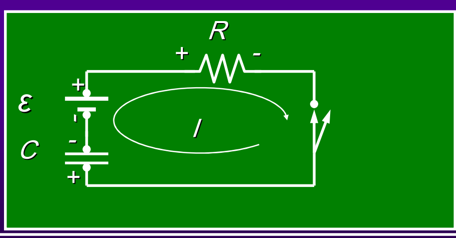
RC Circuit

Consider the following circuit:



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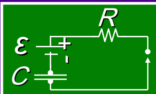
RC Circuit



$\mathcal{E} - q/C - IR = 0$

$\mathcal{E} - q/C - R\,dq/dt = 0$

$I = dq/dt = (\mathcal{E} - q/C)/R$

Let $q = Q(1 - e^{-t/RC})$, with $Q = \mathcal{E}C$

Then $I = dq/dt = (Q/RC)\,e^{-t/RC} = \mathcal{E}/R\,e^{-t/RC}$

$I = \mathcal{E}/R\,e^{-t/RC} = \mathcal{E}/R - \mathcal{E}/R(1 - e^{-t/RC})$ ✓

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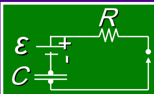
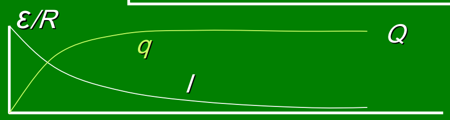
Chapter 28 Direct Current Circuits

RC Circuit



$q = Q(1 - e^{-t/RC})$, with $Q = \mathcal{E}C$

$I = \mathcal{E}/R\,e^{-t/RC}$



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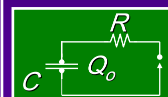
RC Circuit



$-q/C - IR = 0$

$-q/C - R\,dq/dt = 0$

$I = dq/dt = -q/RC$

Let $q = Q_o\,e^{-t/RC}$

Then $I = dq/dt = -(Q_o/RC)\,e^{-t/RC} = -(q/RC)$ ✓

Physics 2220
Chapter 28 Direct Current Circuits

Summary:

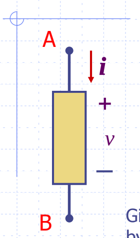
- The equivalent resistance of a series of resistors is equal to the sum of the resistors.
- The reciprocal of the equivalent resistance of a set of parallel resistors is equal to the sum of the reciprocals of the resistances.
- Kirchhoff's rules are:
  1) The sum of all currents into and out of a junction is zero.
  2) The sum all potentials around a loop is zero.

Physics 2220
Chapter 28 Direct Current Circuits

Summary:

- The potential drops across a resistor in the direction of the current flow. $\Delta V = -IR$
- The potential across an emf source is Ɛ in the direction of current flow.
- In a circuit the charge and current in the capacitor are
  $q(t) = Q(1 - e^{-t/RC})$
  $I(t) = -(Q/RC)\,e^{-t/RC}$

Reference Direction



Consider any two-terminal lumped element with terminals A and B as shown in Figure 1. It may be a resistor, inductor or diode. To suggest this generally, we refer to the two-terminal element as a *branch*.

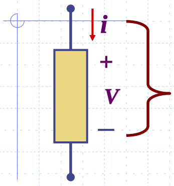
The reference direction for the voltage is indicated by the plus and minus symbols located near terminals *A* and *B*. The reference direction for current is indicated by the arrow.

Given the reference direction for the voltage shown in Fig. by convention *the branch voltage v is positive at time t* (that is, $v(t)>0$) whenever the electrical potential of *A* at time *t* is larger than the electrical potential of *B* at time *t*.

$$v(t) = v_A(t) - v_B(t) \qquad (1.1)$$

Associated reference direction

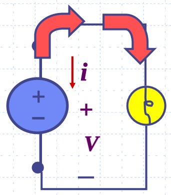
Power Flow



The current variable i is defined as positive into the (+) terminal of the element

"Passive" sign convention

$P = V\,i$ If the *physical* current is positive Power flows ***into*** the element)



The current variable i is defined as positive into the (+) terminal of the element

$P = V\,i$ Here the physical current is negative Power flows ***out of*** the source

Lumped circuits

Lumped circuits are obtained by connecting lumped elements

Typical lumped elements are

- •resistors,
- •capacitors,
- •inductors and
- •transformers

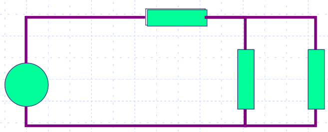
The key properties associated with lumped elements is their small size (compared to the wavelength corresponding to their normal frequency of operation).

From the more general electromagnetic field point of view, lumped elements are point singularities; that is they have negligible physical dimensions.

Network Topology

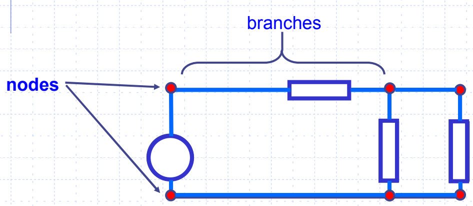
➢ An interconnected set of electrical components is called a **network**.

- Each component of a network is called an **element**.
- Elements are connected by **wires**.



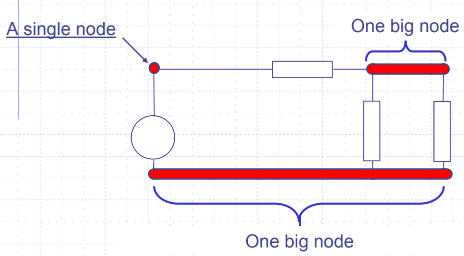
Nodes and Branches

- The interconnections between wires are called **nodes**.
- The wire paths between nodes are called **branches**.



Nodes Connected by Wires Only

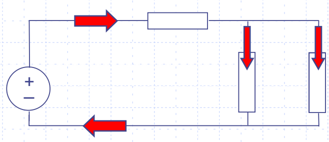
- Two or more nodes connected just by wires can be considered as one single node.



This network as **three** nodes

Current Flow

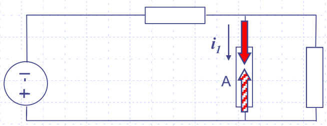
- Current can flow through the branches of a network.
- The direction of current flow is indicated by an arrow.



•Note: The **voltage sources** in the network drive the flow of current through its branches. (More on this idea later.)

Every Current has a Value and a Direction

- The direction is defined by the person drawing the network.
- The value is determined by the properties of the circuit.



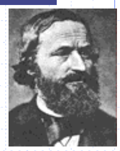
Example:

The arrow above defines "positive" current flow i_1 as downward in branch A.
Suppose that 4 mA of current flows physically downward in branch A. Then $i_1 = 4$ mA.

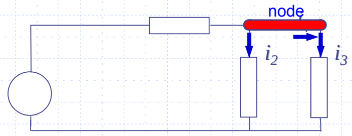
Converse:
Suppose that 4 mA of current flows physically upward in branch A. Then $i_1 = -4$ mA.

Kirchhoff's Current Law

- The sum of currents flowing **into** a node must be balanced by the sum of currents flowing **out** of the node.



Gustav Kirchoff was an 18th century German mathematician



i_1 flows **into** the node
i_2 flows **out** of the node
i_3 flows **out** of the node

$i_1 = i_2 + i_3$

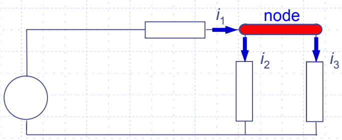
$$\sum i = 0 \quad (1.2)$$

Kirchhoff's Current Law:

$i_1 = i_2 + i_3$

- This equation can also be written in the following form:

$i_1 - i_2 - i_3 = 0$



A formal statement of **Kirchhoff's Current Law**:

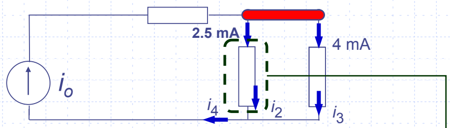
The sum of *all* the currents **entering** a node is zero.

(i_2 and i_3 **leave** the node, hence currents $-i_2$ and $-i_3$ **enter** the node.)

Example 1: Kirchhoff's Current Law:

Q: How much is the current I_o ?

A: i_o = 2.5 mA + 4 mA = 6.5 mA

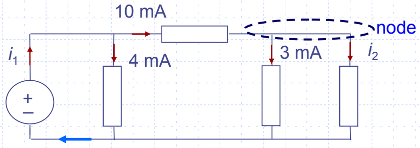


- Note that a "node" need not be a discrete point
- The dotted circle is a node with 2.5 mA entering
- Hence i_2 = 2.5 mA exits the "node".
  Similarly, i_3 = 4 mA.
- From KCL, $i_4 = i_2 + i_3$ = 6.5 mA, and $I_o = i_4$

Example 2: Kirchhoff's Current Law:

Q: How much are the currents i_1 and i_2 ?

A: i_2 = 10 mA – 3 mA = 7 mA
i_1 = 10 mA + 4 mA = 14 mA



4 mA + 3 mA + 7 mA = 14 mA

Sometimes Kirchhoff's Current Law is abbreviated just by

KCL

Review: Different ways to state KCL:

- ✓ The sum of *all* currents **entering** a node must be zero.
- ✓ The net current entering a node must be zero.
- ✓ Whatever flows into a node must come out.

more to follow…

General View of Networks

A network is an **interconnection** of elements via nodes and branches

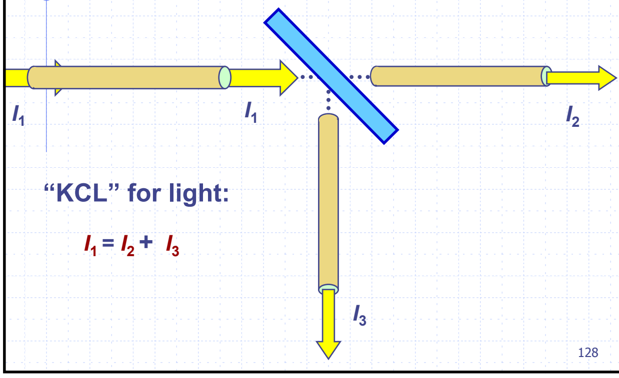
There are many kinds of networks:

Elements	Network	Connection Paths
•Electrical components	Circuit	Wires
•Computers	Internet	Fiber Optics
•Organs	Circulatory System	Blood Vessels

Kirchoff's Current Law applies to all these kinds of networks!

Kirchhoff's Current Law applies to all types of networks

Fiber optic network (***I*** is **light intensity**)

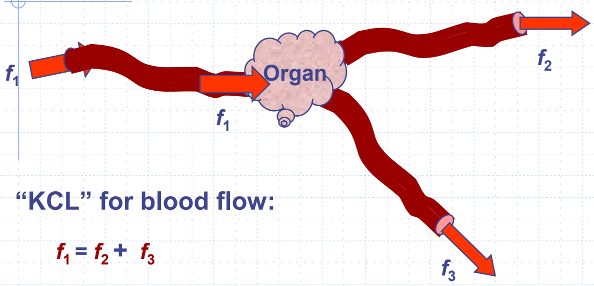


"KCL" for light:

$I_1 = I_2 + I_3$

Kirchhoff's Current Law applies to all types of networks

Human Blood Vessels (***f*** is **blood flow rate**)

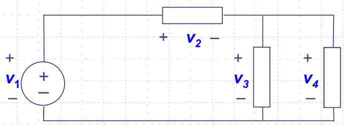


"KCL" for blood flow:

$f_1 = f_2 + f_3$

Voltage

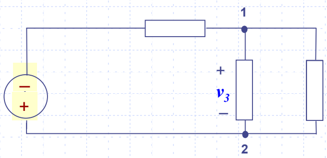
- **Voltages** are measured *across* the branches of a network, from one node to another.
- The **direction** of a voltage is indicated by + and – signs.



- Remember: The **voltage sources** in the network drive the flow of current through the branches.

Every Voltage has a Value and a Polarity

- The polarity is defined by the person drawing the network.
- The value is determined by the properties of the circuit.



Example:

The plus and minus signs above define the polarity of v_3 as "positive" from node 1 to node 2.

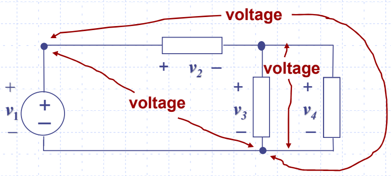
Suppose that +5 V appears physically from node 1 to node 2 . Then v_3 = 5 V.

Converse:

Suppose that +5 V appears physically from node 2 to node 1 . Then v_3 = –5 V.

Kirchhoff's Voltage Law

The voltage measured between any two nodes does not depend of the path taken.



Example of KVL: $v_1 = v_2 + v_3$

Similarly: $v_1 = v_2 + v_4$

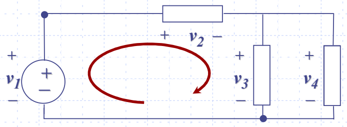
and: $v_3 = v_4$

Kirchhoff's Voltage Law:

$$v_1 = v_2 + v_3 \qquad (1.3)$$

- This equation can also be written in the following form:

$$-v_1 + v_2 + v_3 = 0$$



A formal statement of **Kirchhoff's Voltage Law**:

The sum of voltages around a **closed loop** is zero.

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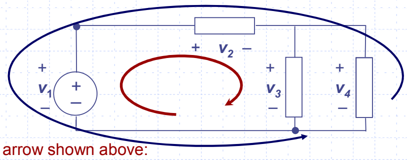
Definition of KVL

"The sum of voltages around a closed loop is zero."

- Define an arrow direction around a closed loop.
- Sum the voltages as the are encountered in going around the loop.
- If the arrow first encounters a **plus** sign, enter that voltage with a (+) into the KVL equation.
- If the arrow first encounters a **minus** sign, enter that voltage with a (–) into the KVL equation.



For the arrow shown above: $-v_1 + v_2 + v_3 = 0$

For the outer arrow: $-v_4 - v_2 + v_1 = 0$

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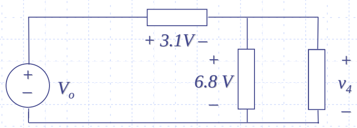
Example 1: Kirchhoff's Voltage Law:

Q: How much is the voltage V_o ?

A: V_o = 3.1 V + 6.8 V



Q: How much is the voltage v_4 ?

A: v_4 = 6.8 V

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Example 2: Kirchhoff's Voltage Law:

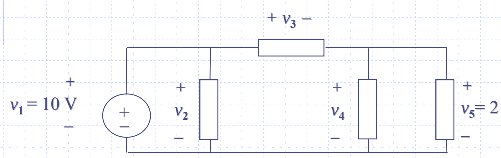
Q: If v_1 = 10 V and v_5 = 2 V, what are v_2, v_3, and v_4?

A:

v_2 = 10 V

v_3 = 10 V – 2 V = 8 V

v_4 = 2 V



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Wavelength and Dimension of the Circuit

What happens when the dimensions of a circuit become comparable to or even larger than the wavelength associated with the highest frequencies of interest?

Let d be the largest dimension of the circuit, c the velocity of propagation of electromagnetic waves, λ the wavelength of the highest frequency of interest, and f the frequency. The condition states that

d is of the order of a larger than λ (1.4)

Now $\tau = d / c$ Is the time required for electromagnetic waves to propagate from one end of the circuit to the other. Since $f\lambda = c$, $\lambda / c = 1/f = T$ where T is the period of the highest frequency of interest

τ is of the order of a larger than T (1.5)

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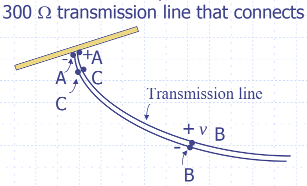
Thus, recalling the remarks concerning the applicability of *KCL* and *KVL* at high frequencies, we may say that *KCL* and *KVL* hold for any lumped circuit as long as the propagation time of electromagnetic waves through the medium surrounding the circuit is negligible small compared with the period of the highest frequency of interest.

Example

Let us consider a dipole antenna of an FM broadcast receiver and the 300 Ω transmission line that connects it to the receiver.



The transmission line consists of two parallel copper wires that are held at a constant distance from one another by simple insulating plastic.

The transmission line is infinitely long to the right.

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Summary

1. Kirchhoff's laws and the lumped-element model of a circuit are valid provided that the largest physical dimension of a circuit is small compared with the wavelength corresponding to the highest frequency under consideration
2. KCL states that for any lumped electric circuit, for any of its nodes, and at any time, the algebraic sum of all the branch currents leaving the node is zero
3. KVL states that for any lumped electric circuit, for any of its loops, and at any time, the algebraic sum of all the branch voltages around the loop is zero $\sum_{loop} v_i = 0$
4. Kirchhoff's laws are linear constraints on the branch voltages and branch currents. Furthermore, they are independent of the nature of the elements

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Ohm's Law

"Current (I) is proportional to Voltage (V) and inversely proportional to Resistance (R)"

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

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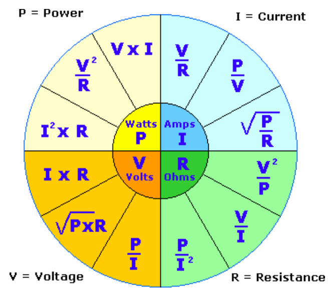
Ohm's Law and Power Formulas



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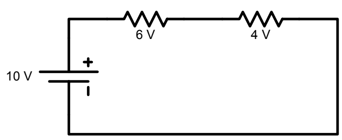
Kirchhoff's Voltage Law

- Used in series circuits
- "The sum of the voltage drops equals the applied voltage", or…
- "The sum of the voltage drops around a closed loop equals zero"



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Three Main Invisible Quantities

- Voltage, V, Volts
  - Provides the "push"
- Current, I, Amperes (Amps)
  - Flow of Electrons
  - Amount of Current is dependent on Voltage and Resistance
- Resistance, R, Ohms (Ω)
  - Limits the amount of current

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Kirchhoff's Law's

- Kirchhoff's Voltage Law
  - "The sum of the voltage drops equals the applied voltage", or…
  - "The sum of the voltage drops around a closed loop equals zero"
  - Used in series circuits
- Kirchhoff's Current Law
  - "The current entering a junction must equal the current leaving the junction"
  - Use in parallel circuits.

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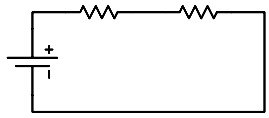
Series Circuits

- One current path, therefore the current is the same everywhere



- Total resistance is the sum of the individual resistances

$$R_T = R_1 + R_2 + \ldots$$

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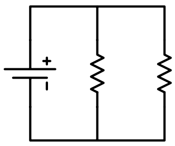
Parallel Circuits

- More than one current path



- Total current is the sum of the individual currents

$$I_T = I_1 + I_2 + \ldots$$

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Parallel Circuits (2)

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$$

$$= \frac{R_1 \times R_2}{R_1 + R_2} (if\ 2\ only)$$

$$= \frac{R}{n} (if\ \ the\ same\ value$$

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Measures of Electricity

Table 4-1 Measures of electricity (continued)

Unit	Definition	An Example As Applied to a Computer
Ohms (measures resistance)	Abbreviated with the symbol Ω (for example, 20 Ω). Devices are rated according to how much resistance to electrical current they offer. The ohm rating of a resistor or other electrical device is often written somewhere on the device. The resistance of a device is measured when the device is not connected to an electrical system.	Current can flow in typical computer cables and wires with a resistance of near zero Ω.
Watts (measures power)	Abbreviated W (for example, 20 W). Watts are calculated by multiplying volts by amps.	A computer power supply is rated at 200 to 600 W.

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Relationships Among Voltage, Current, and Resistance

- **Voltage** and **current** have a **direct relationship**
  - When voltage increases, current increases
- **Resistance** has an **inverse relationship with voltage and current**
  - As resistance increases, either current or voltage decreases
  - As resistance decreases, either current or voltage increases (Ohm's Law)

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