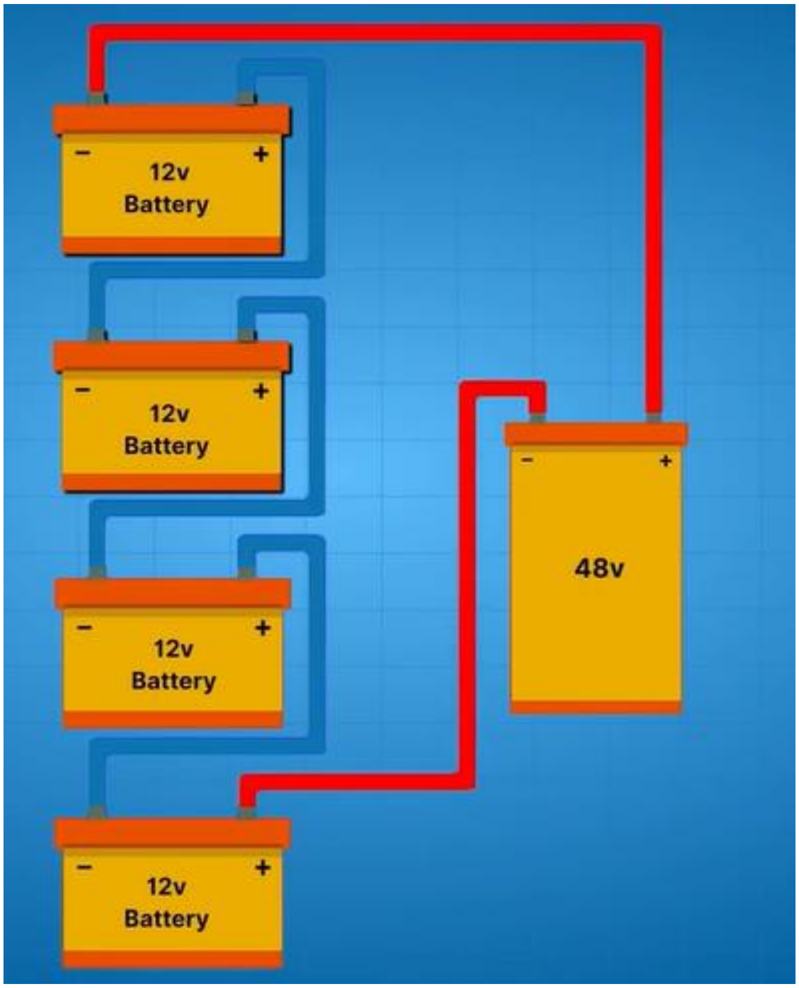
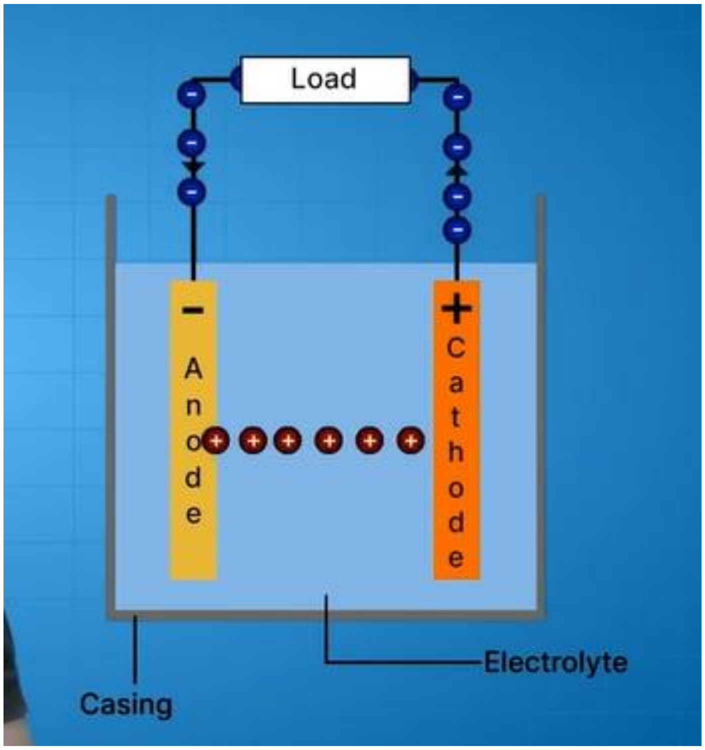
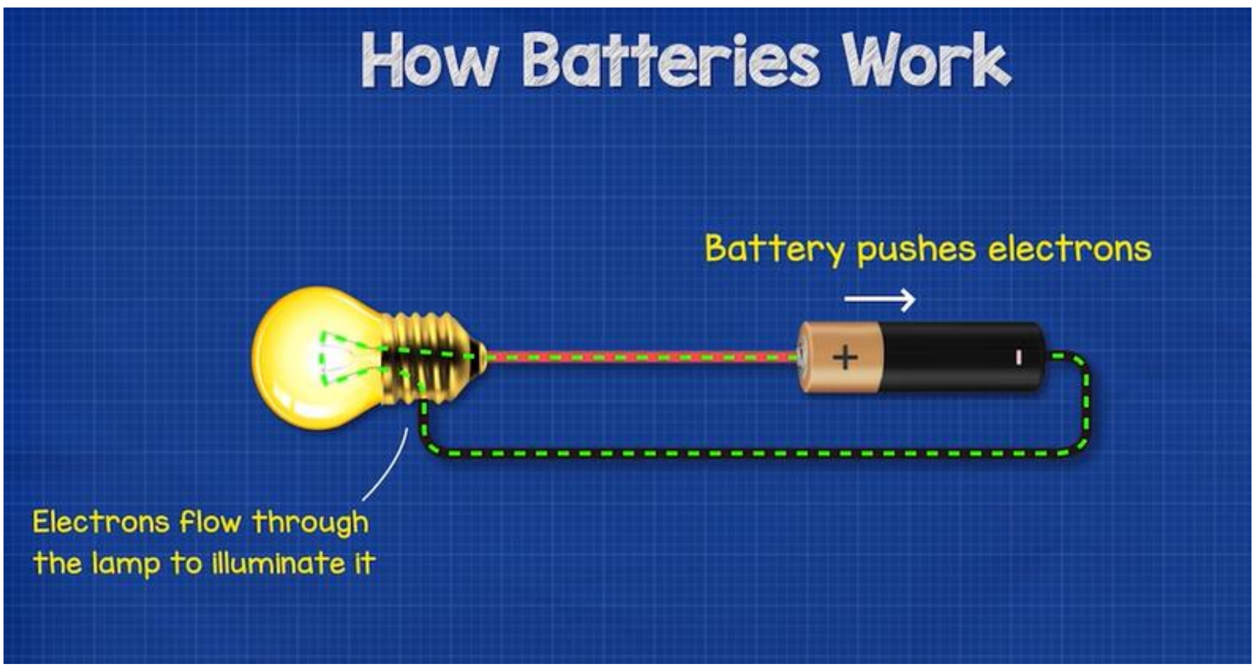
To learn basics of battery, its charge & discharge characteristics

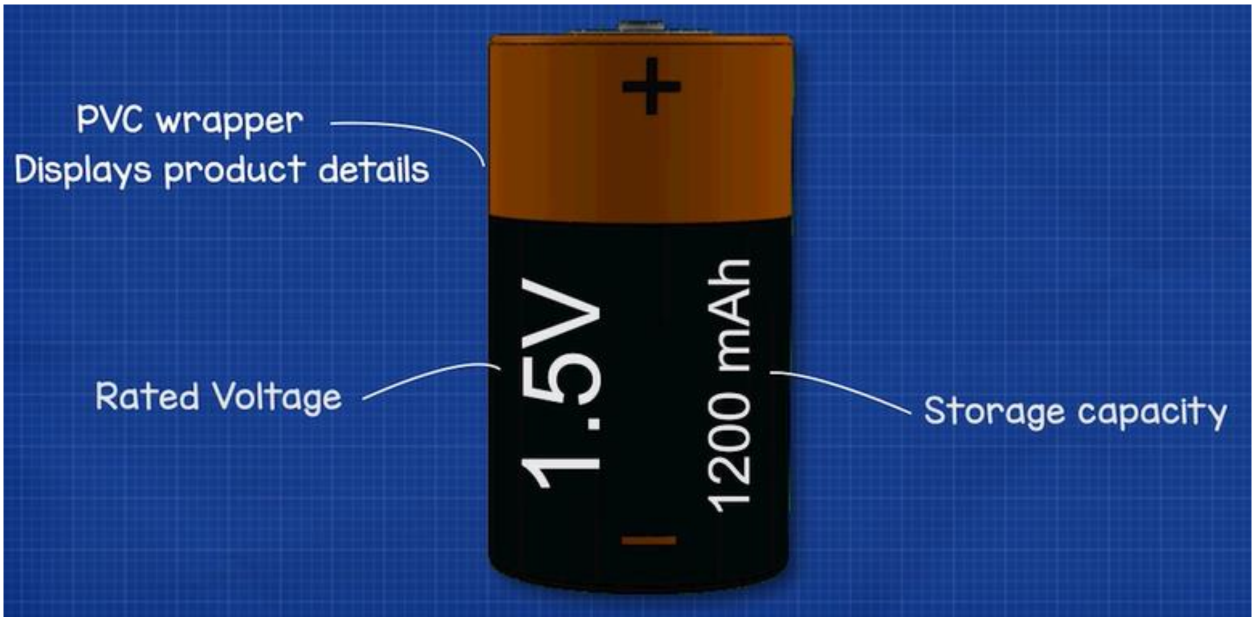
To find the capacity of battery at different discharge rates

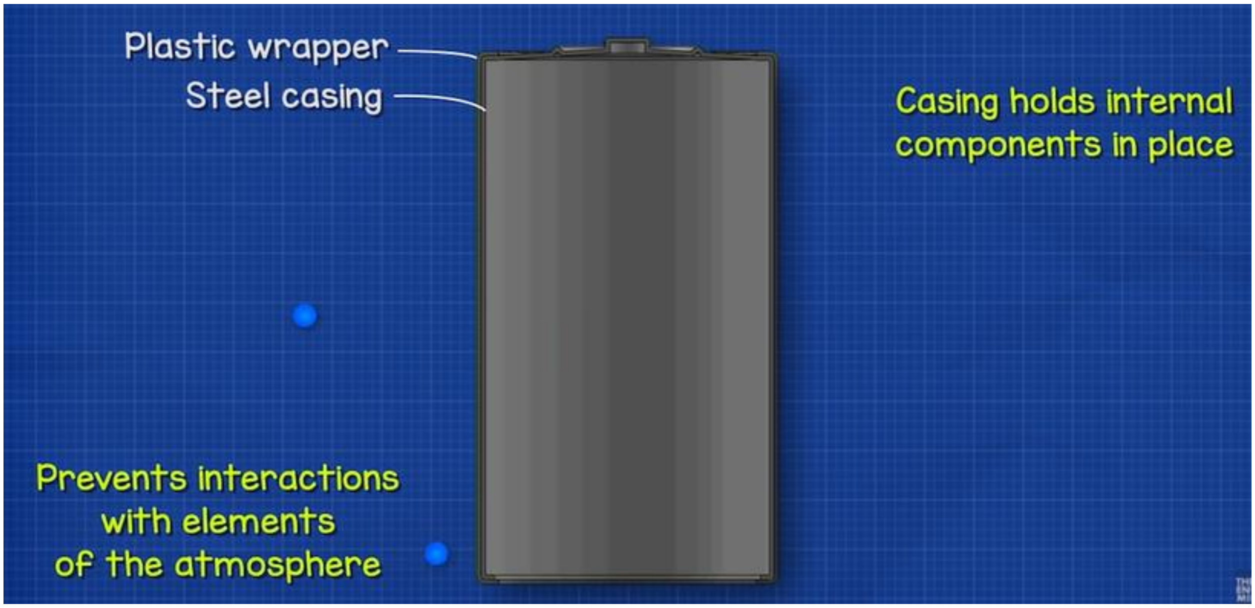


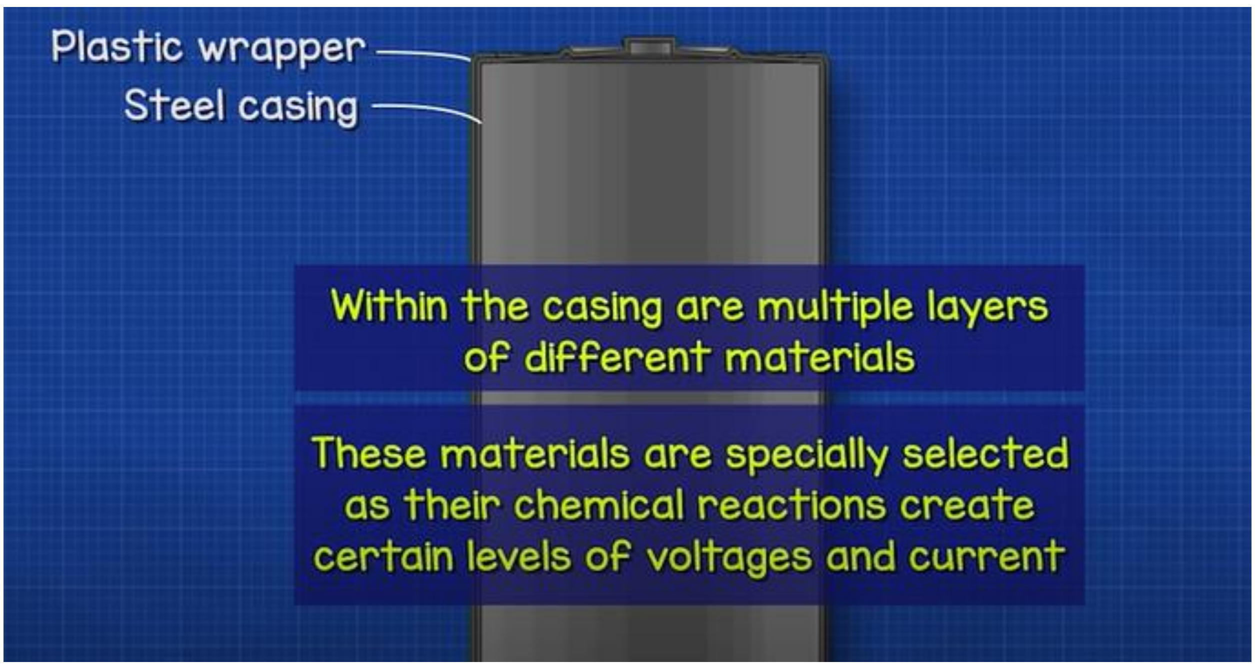

Load
Anode
Cathode
Electrolyte
Casing

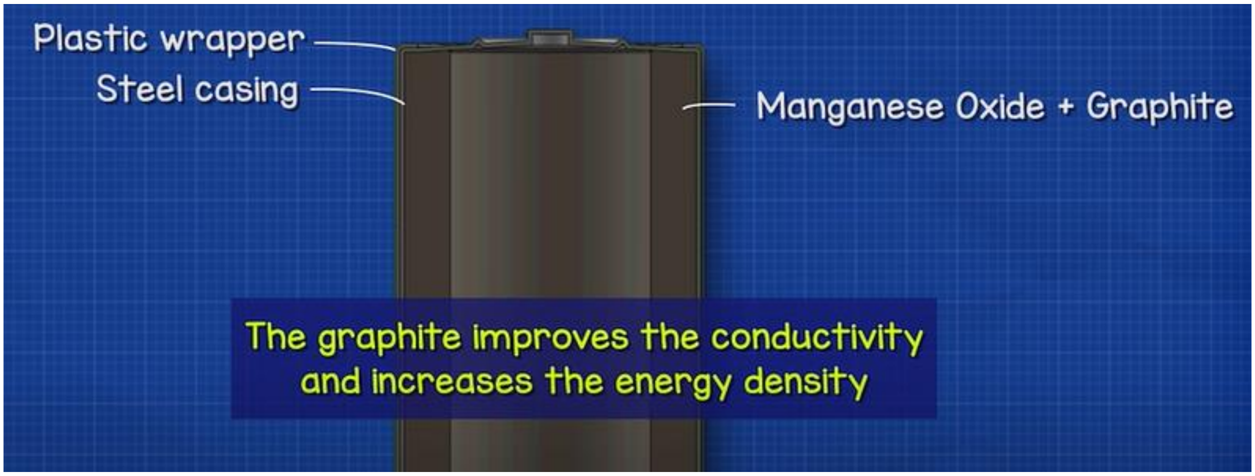

How Batteries Work
Battery pushes electrons
Electrons flow through
the lamp to illuminate it

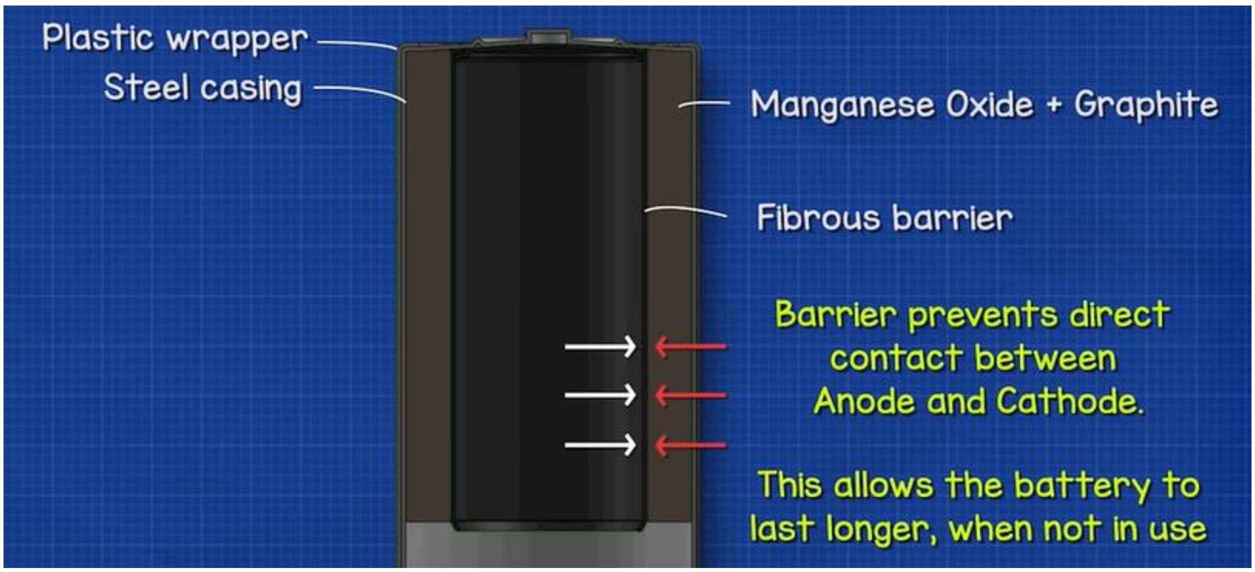

RECHARGEABLE
ALKALINE
Some batteries can be recharged, this will be clearly stated on the c
Standard Alkaline batteries can't be recharged

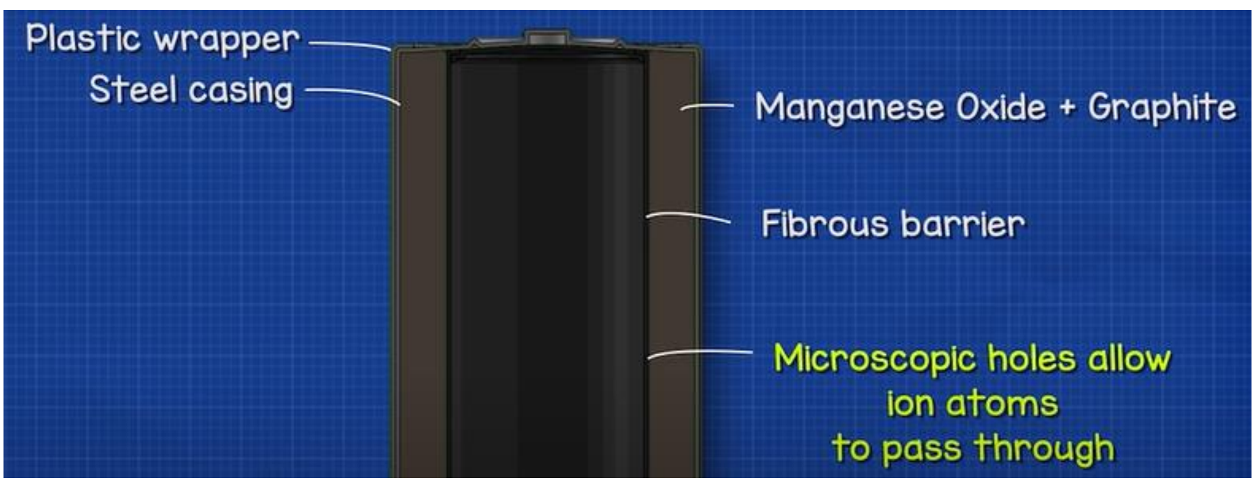

PVC wrapper
Displays product details
+
1.5V
1200 mAh
Rated Voltage
Storage capacity

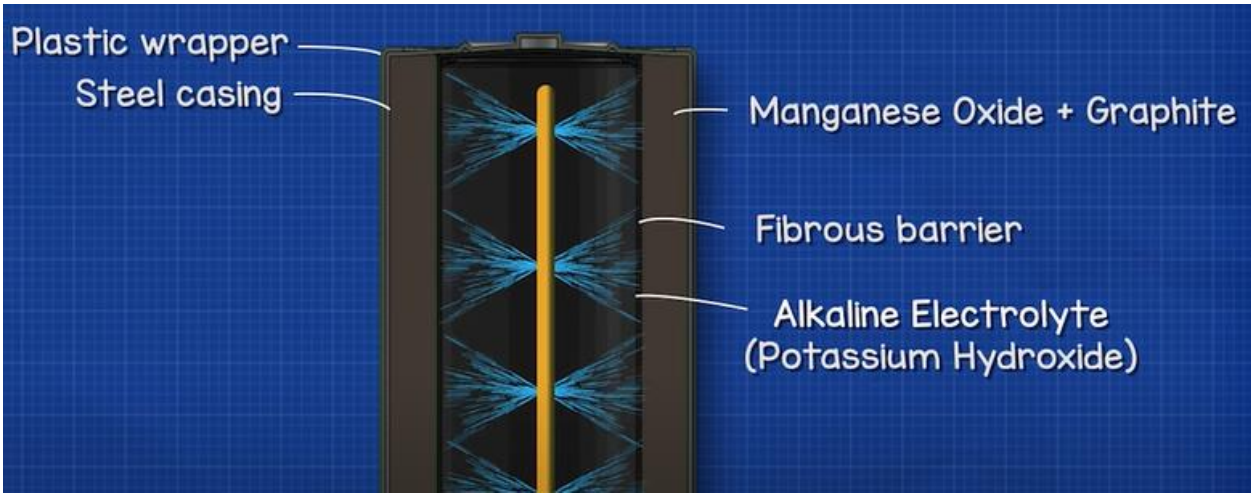

Plastic wrapper
Steel casing
Casing holds internal components in place
Prevents interactions with elements of the atmosphere

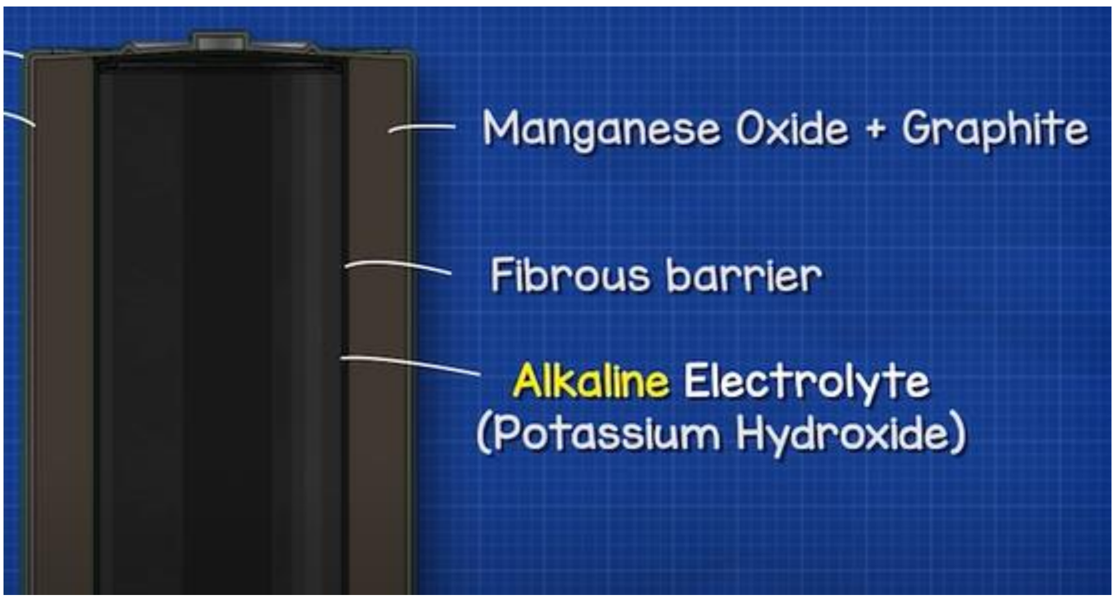

Plastic wrapper
Steel casing
Within the casing are multiple layers of different materials
These materials are specially selected as their chemical reactions create certain levels of voltages and current

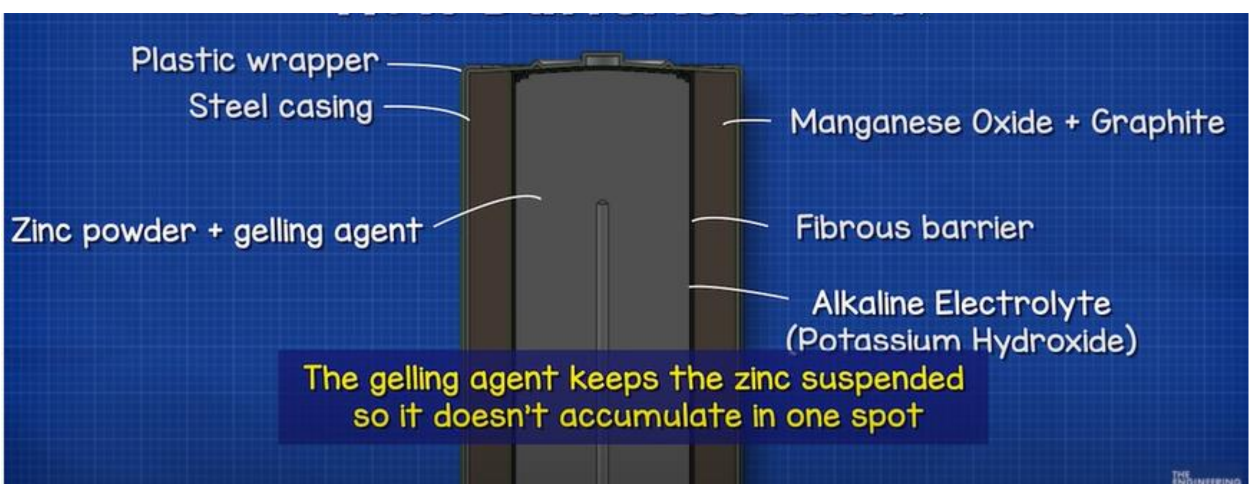

Plastic wrapper
Steel casing
Manganese Oxide + Graphite
The graphite improves the conductivity and increases the energy density

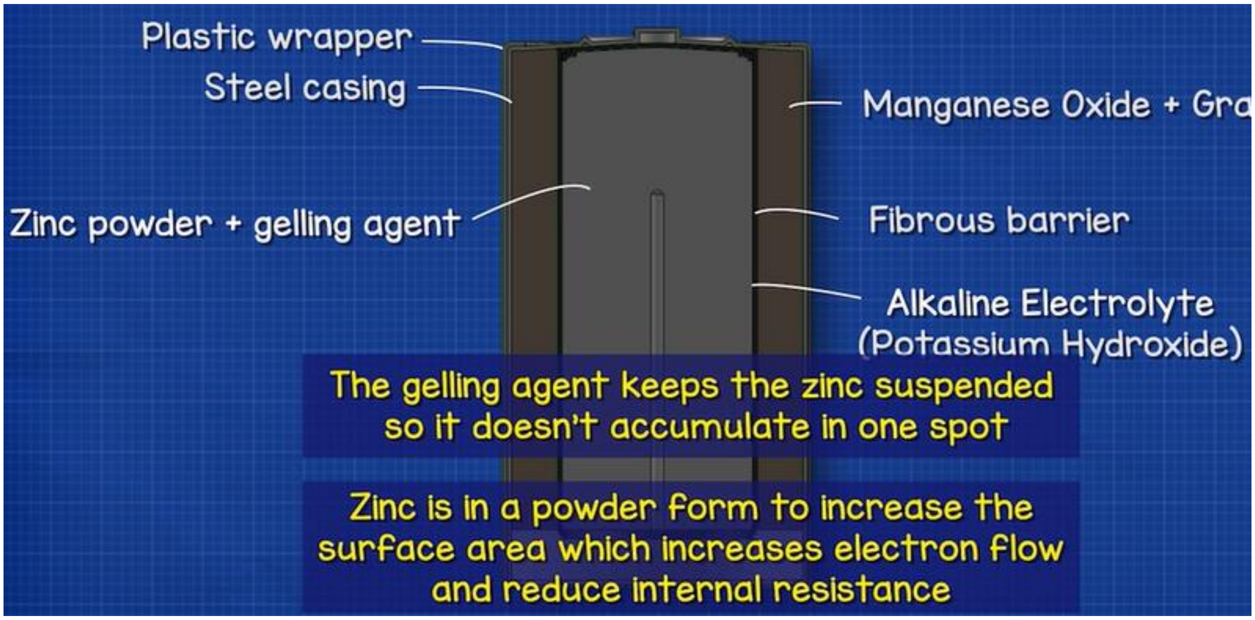

Plastic wrapper
Steel casing
Manganese Oxide + Graphite
Fibrous barrier
Barrier prevents direct contact between Anode and Cathode.
This allows the battery to last longer, when not in use

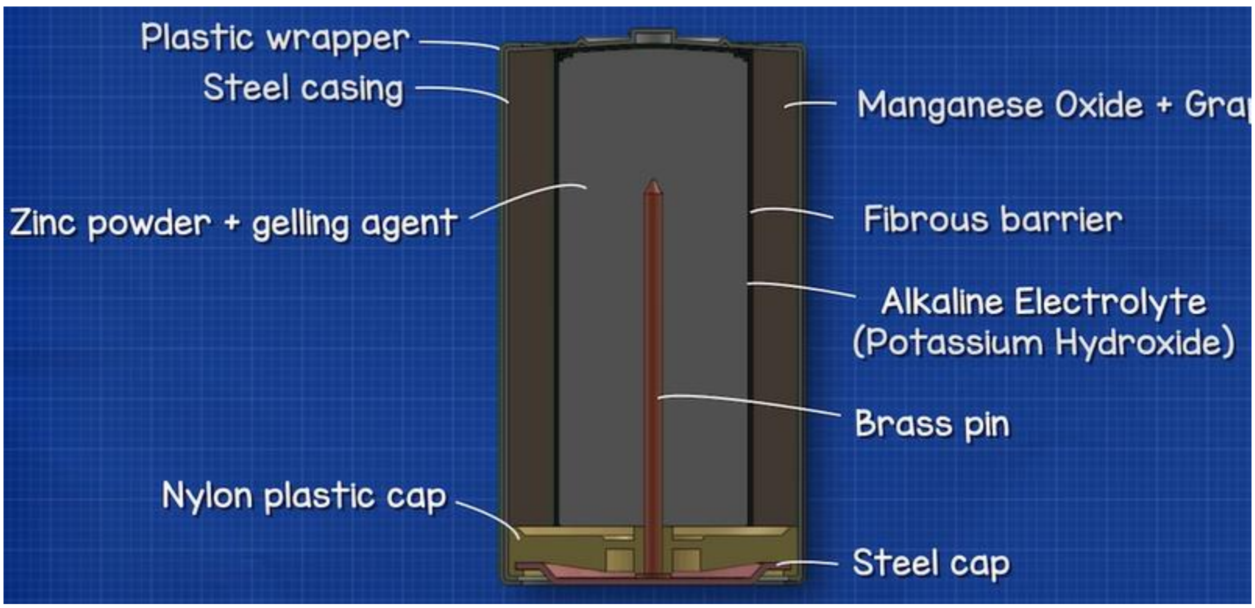

Plastic wrapper
Steel casing
Manganese Oxide + Graphite
Fibrous barrier
Microscopic holes allow ion atoms to pass through

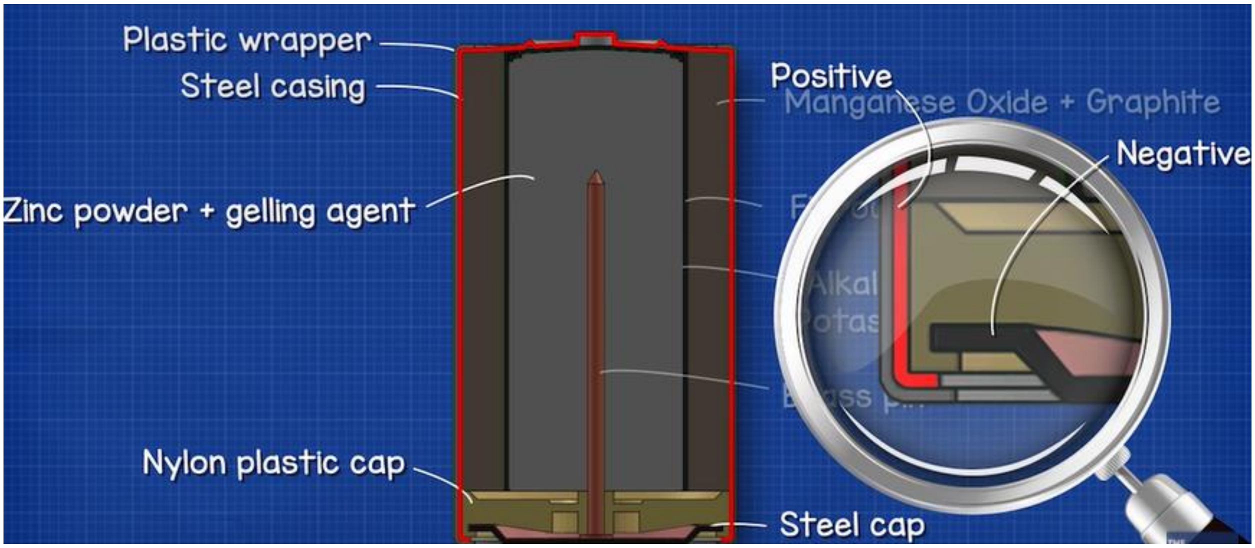

Plastic wrapper
Steel casing
Manganese Oxide + Graphite
Fibrous barrier
Alkaline Electrolyte
(Potassium Hydroxide)

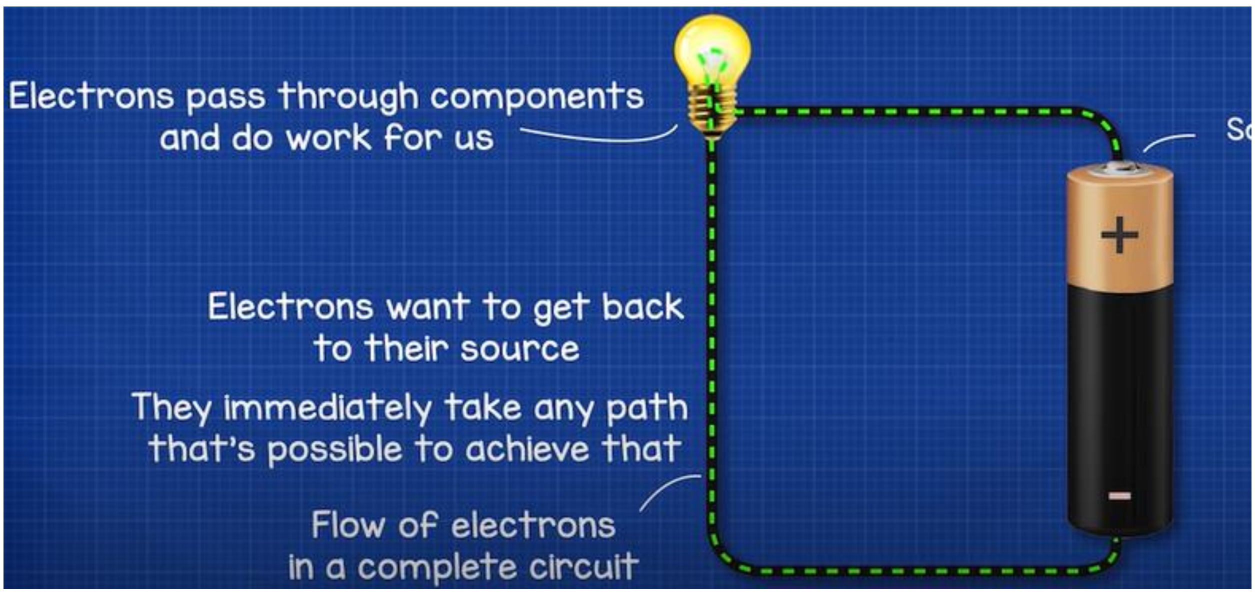

Manganese Oxide + Graphite
Fibrous barrier
Alkaline Electrolyte
(Potassium Hydroxide)

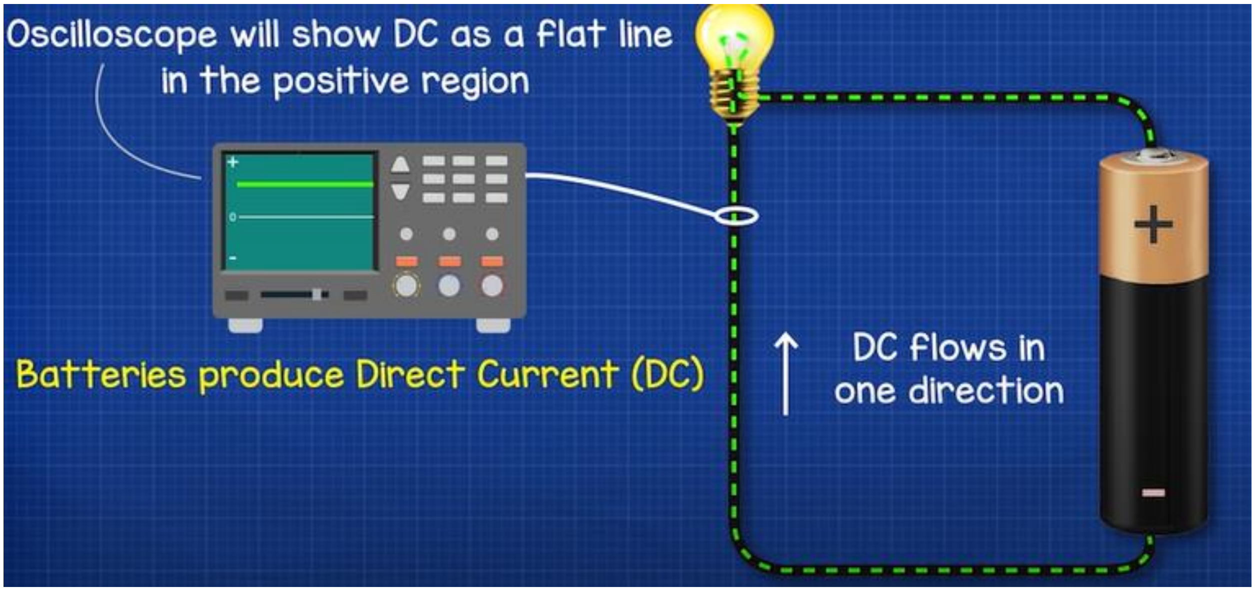

Plastic wrapper
Steel casing
Manganese Oxide + Graphite
Zinc powder + gelling agent
Fibrous barrier
Alkaline Electrolyte
(Potassium Hydroxide)
The gelling agent keeps the zinc suspended
so it doesn't accumulate in one spot

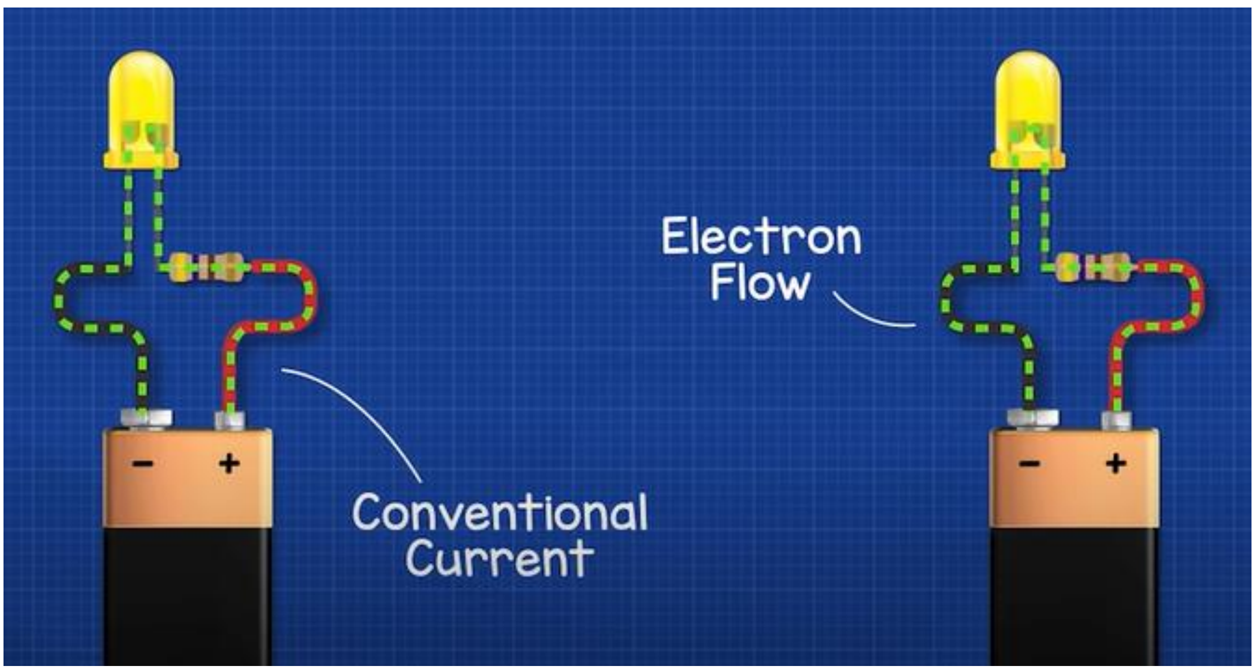

Plastic wrapper
Steel casing
Manganese Oxide + Gra
Zinc powder + gelling agent
Fibrous barrier
Alkaline Electrolyte (Potassium Hydroxide)
The gelling agent keeps the zinc suspended so it doesn't accumulate in one spot
Zinc is in a powder form to increase the surface area which increases electron flow and reduce internal resistance

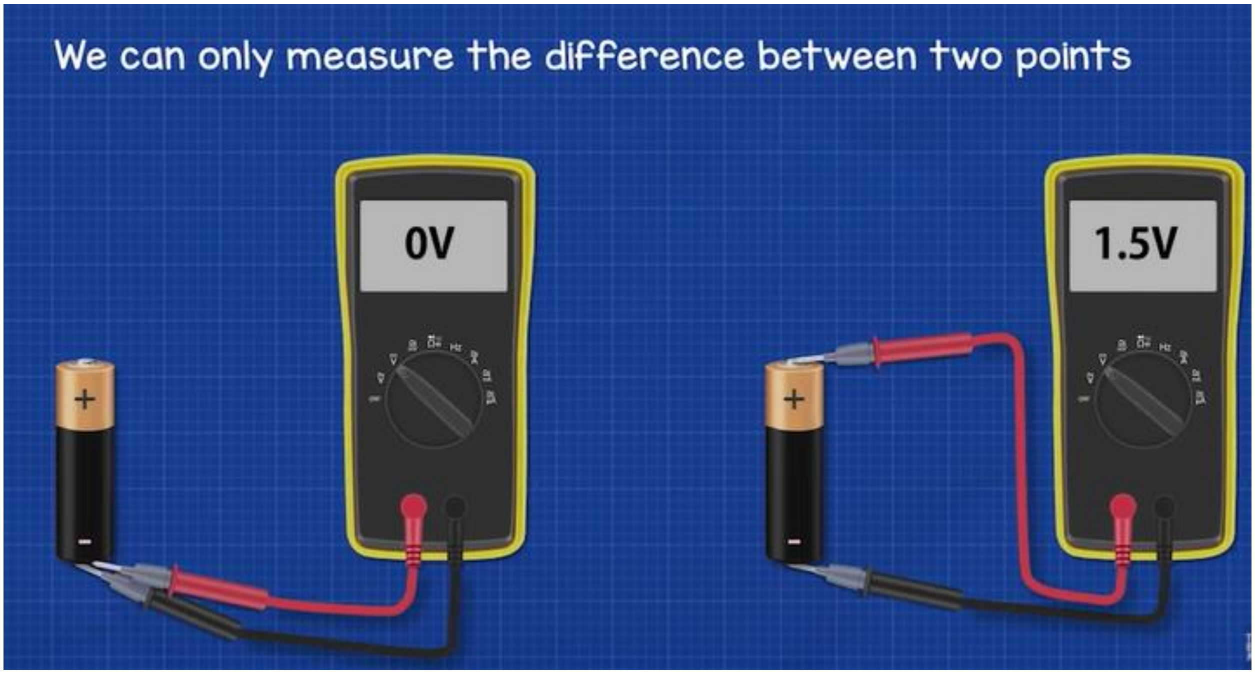

Plastic wrapper
Steel casing
Manganese Oxide + Gra
Zinc powder + gelling agent
Fibrous barrier
Alkaline Electrolyte (Potassium Hydroxide)
Brass pin
Nylon plastic cap
Steel cap

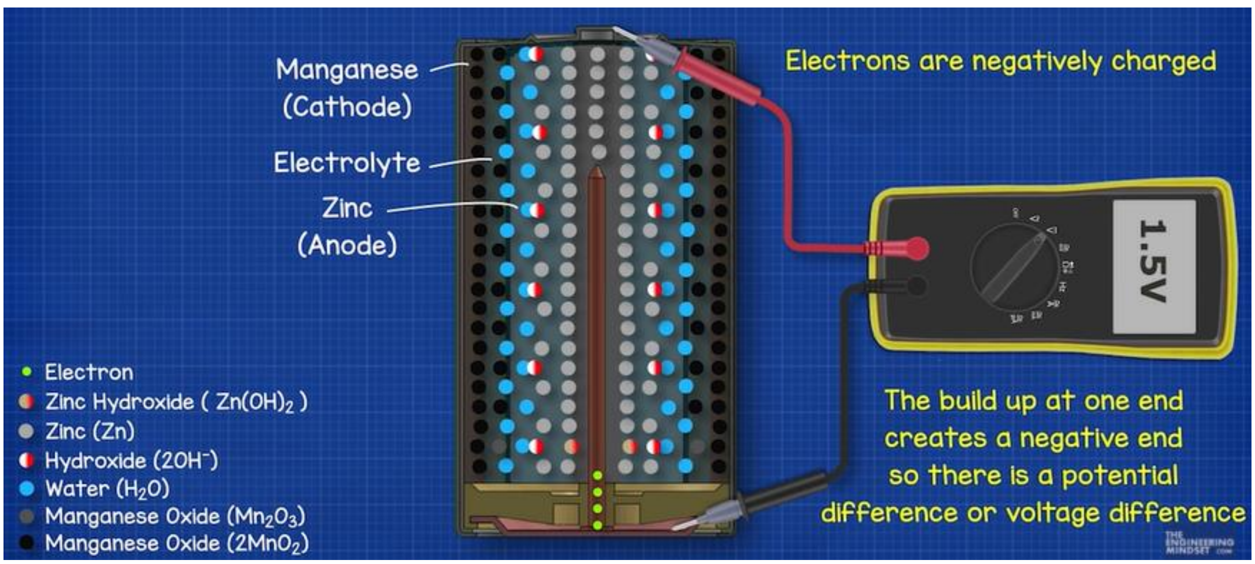

Plastic wrapper
Steel casing
Positive
Manganese Oxide + Graphite
Negative
Zinc powder + gelling agent
Nylon plastic cap
Steel cap

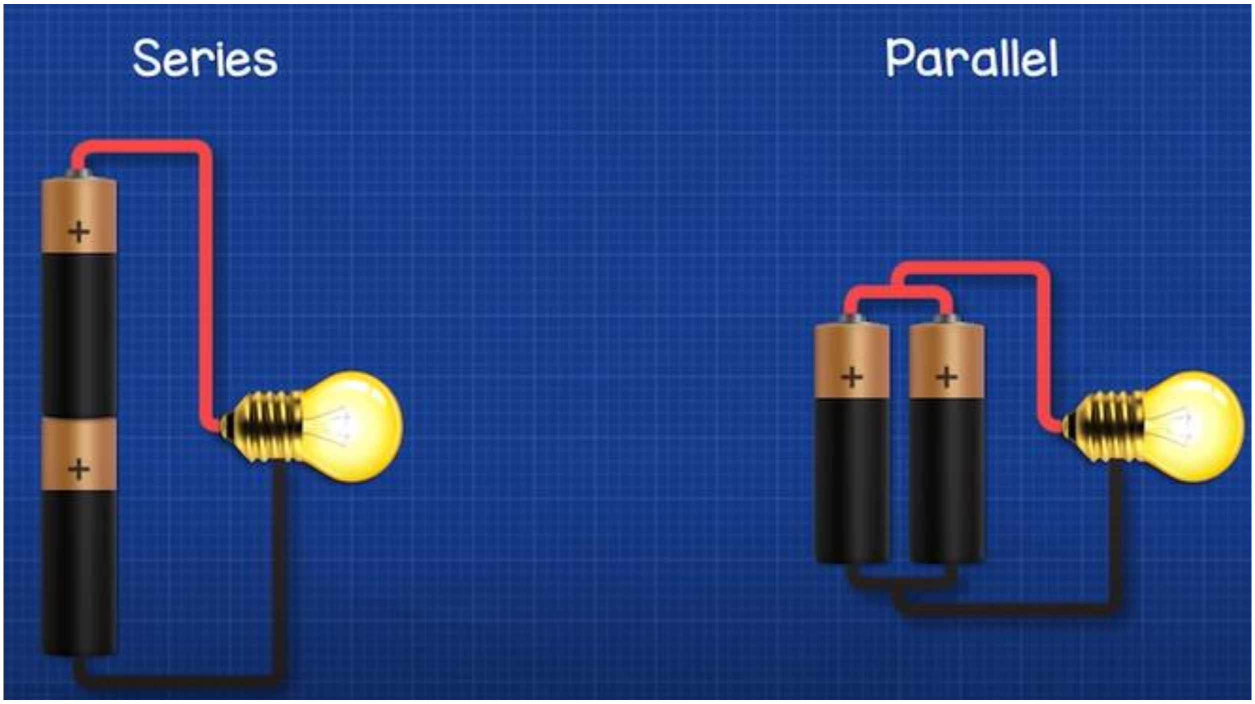

Electrons pass through components and do work for us
Electrons want to get back to their source
They immediately take any path that's possible to achieve that
Flow of electrons in a complete circuit

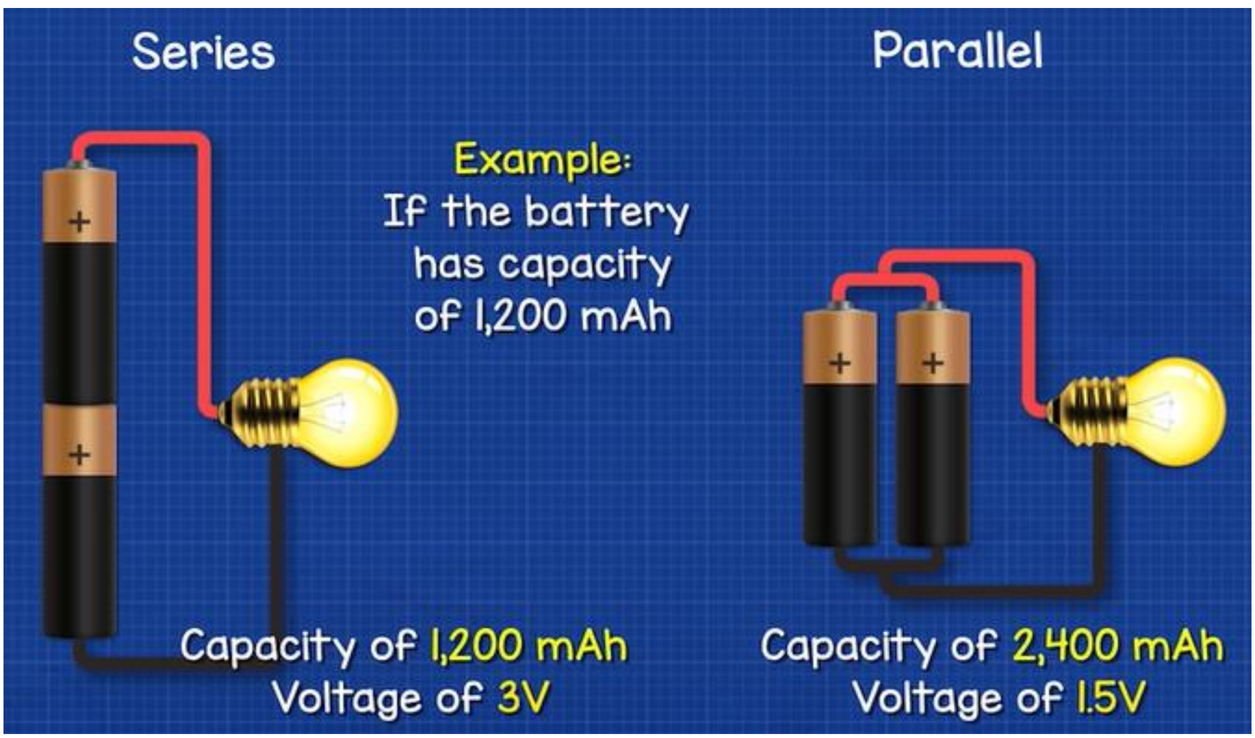

Oscilloscope will show DC as a flat line
in the positive region
Batteries produce Direct Current (DC)
DC flows in
one direction

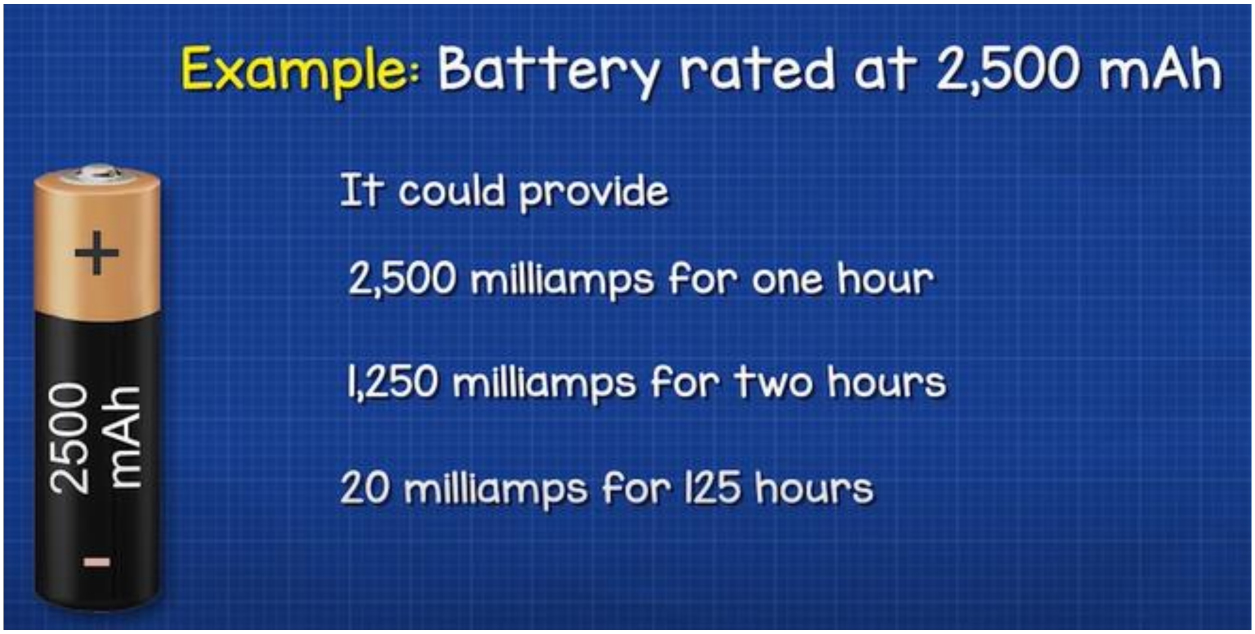

Electron
Flow
Conventional
Current

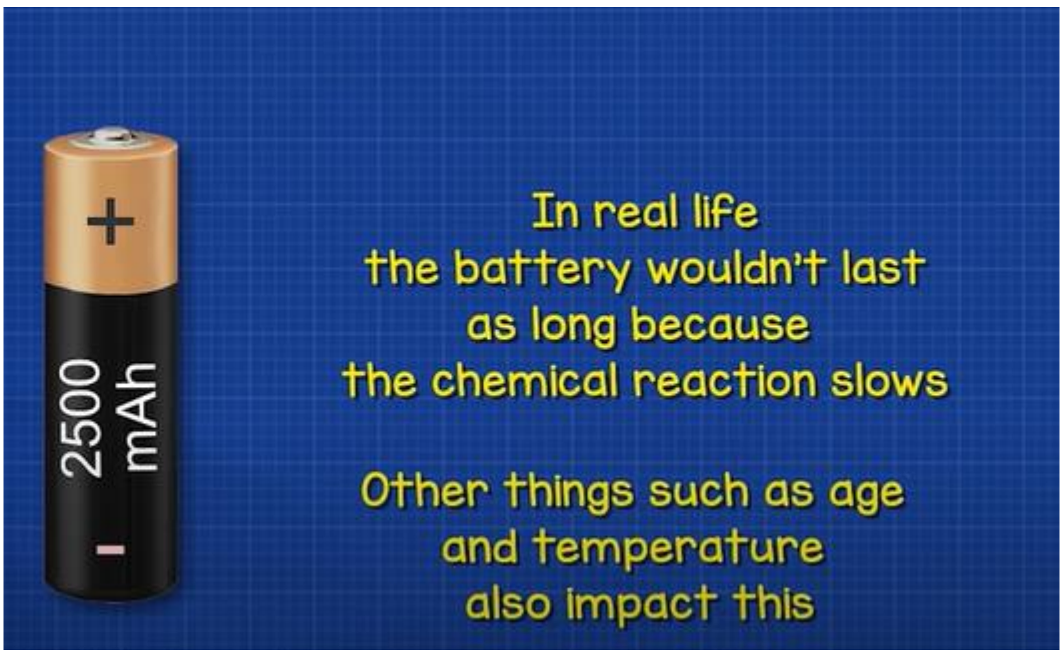

We can only measure the difference between two points
0V
1.5V

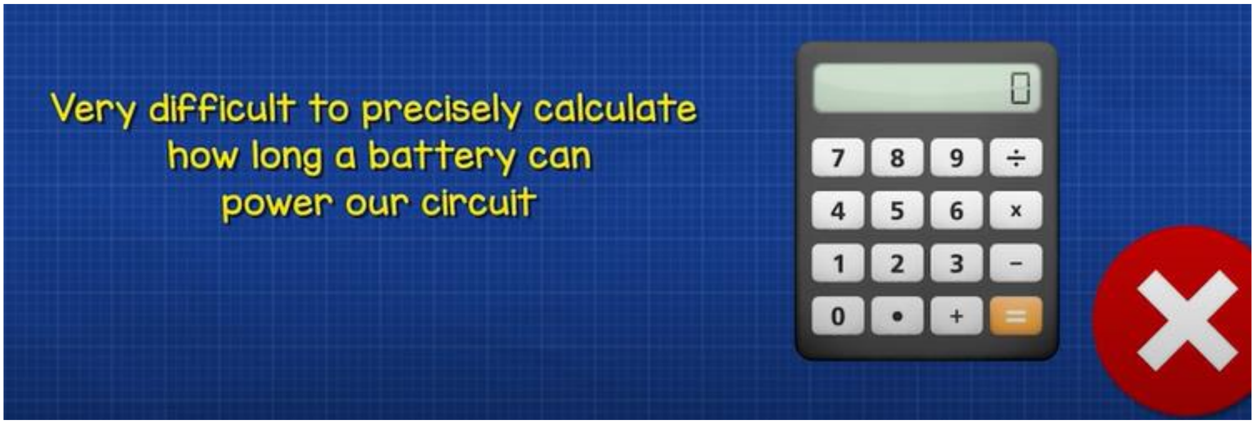

Manganese
(Cathode)
Electrolyte
Zinc
(Anode)
Electrons are negatively charged
1.5V
Electron
Zinc Hydroxide (Zn(OH)2)
Zinc (Zn)
Hydroxide (2OH-)
Water (H2O)
Manganese Oxide (Mn2O3)
Manganese Oxide (2MnO2)
The build up at one end
creates a negative end
so there is a potential
difference or voltage difference

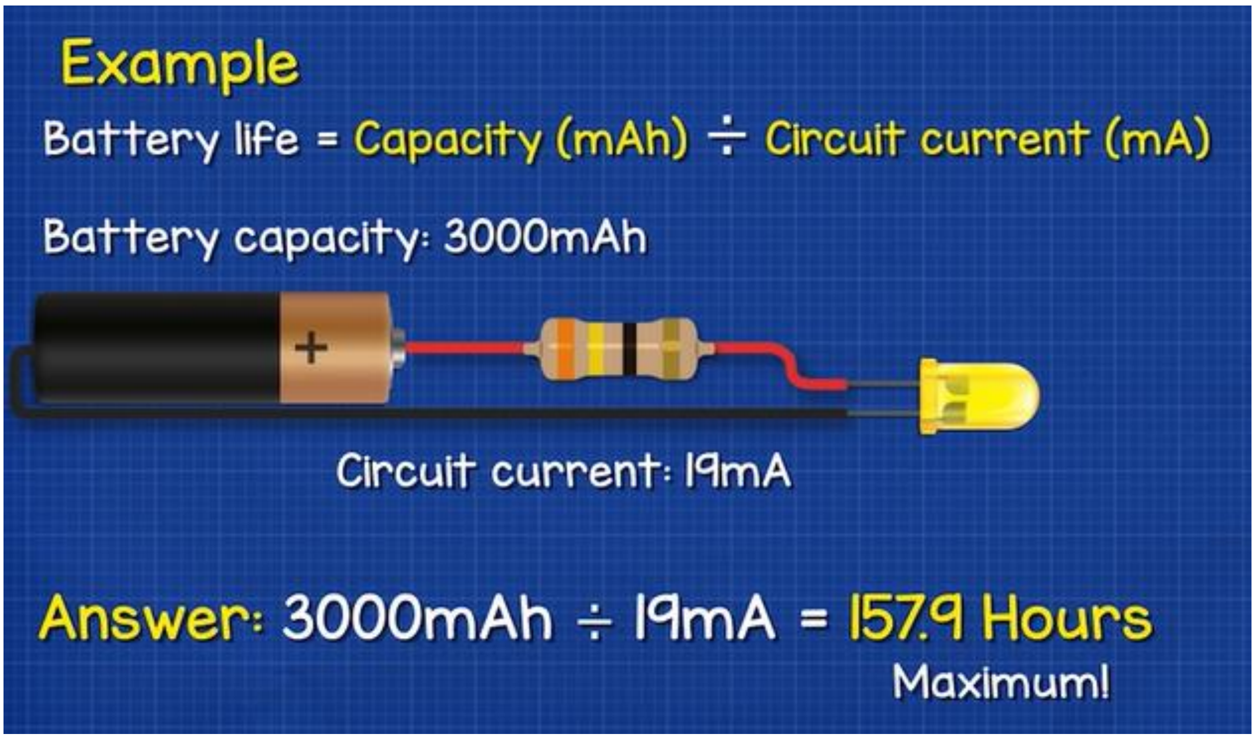

Series
Parallel

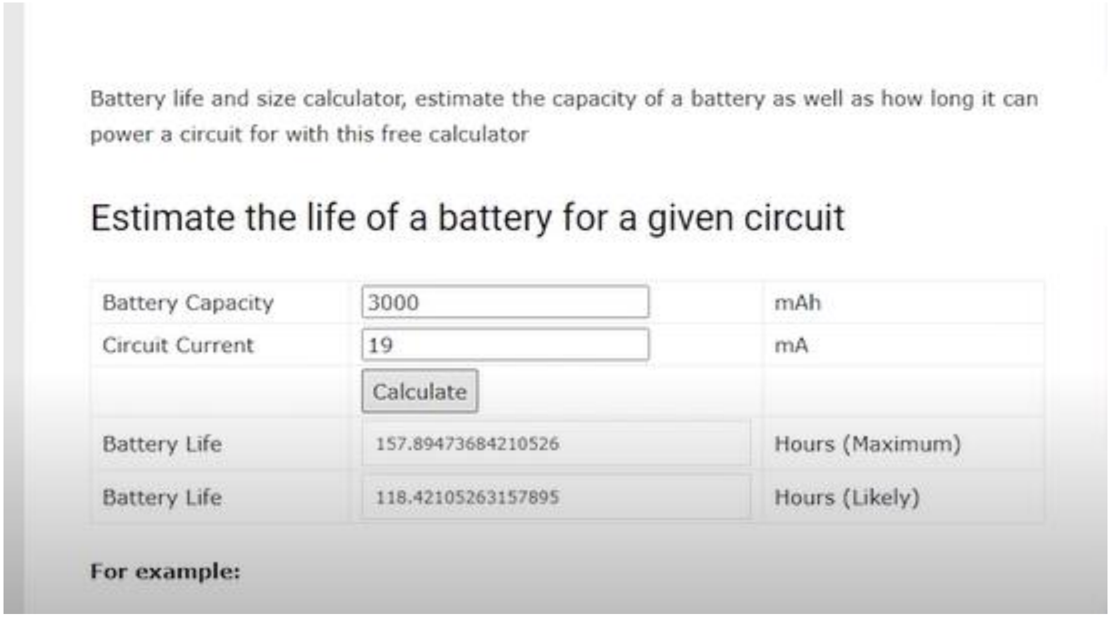

Series
Parallel
Example:
If the battery
has capacity
of 1,200 mAh
Capacity of 1,200 mAh
Voltage of 3V
Capacity of 2,400 mAh
Voltage of 1.5V


Example: Battery rated at 2,500 mAh
It could provide
2,500 milliamps for one hour
1,250 milliamps for two hours
20 milliamps for 125 hours
2500 mAh
+
-


In real life
the battery wouldn't last
as long because
the chemical reaction slows
Other things such as age
and temperature
also impact this
2500 mAh
+
-


Very difficult to precisely calculate
how long a battery can
power our circuit


Example
Battery life = Capacity (mAh) ÷ Circuit current (mA)
Battery capacity: 3000mAh
Circuit current: 19mA
Answer: 3000mAh ÷ 19mA = 157.9 Hours
Maximum!

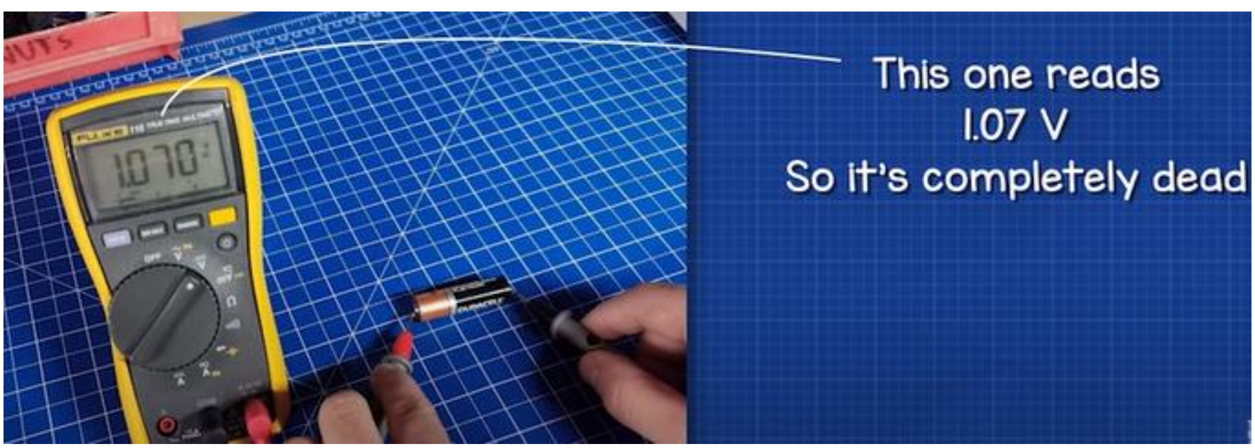


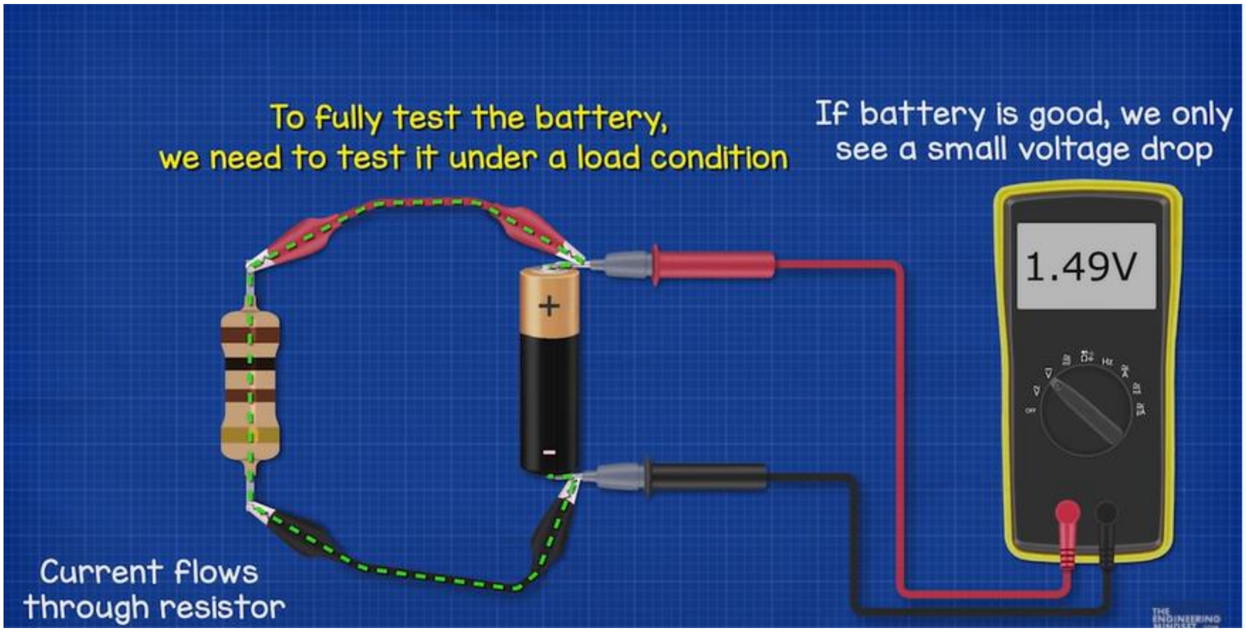
Battery life and size calculator, estimate the capacity of a battery as well as how long it can power a circuit for with this free calculator

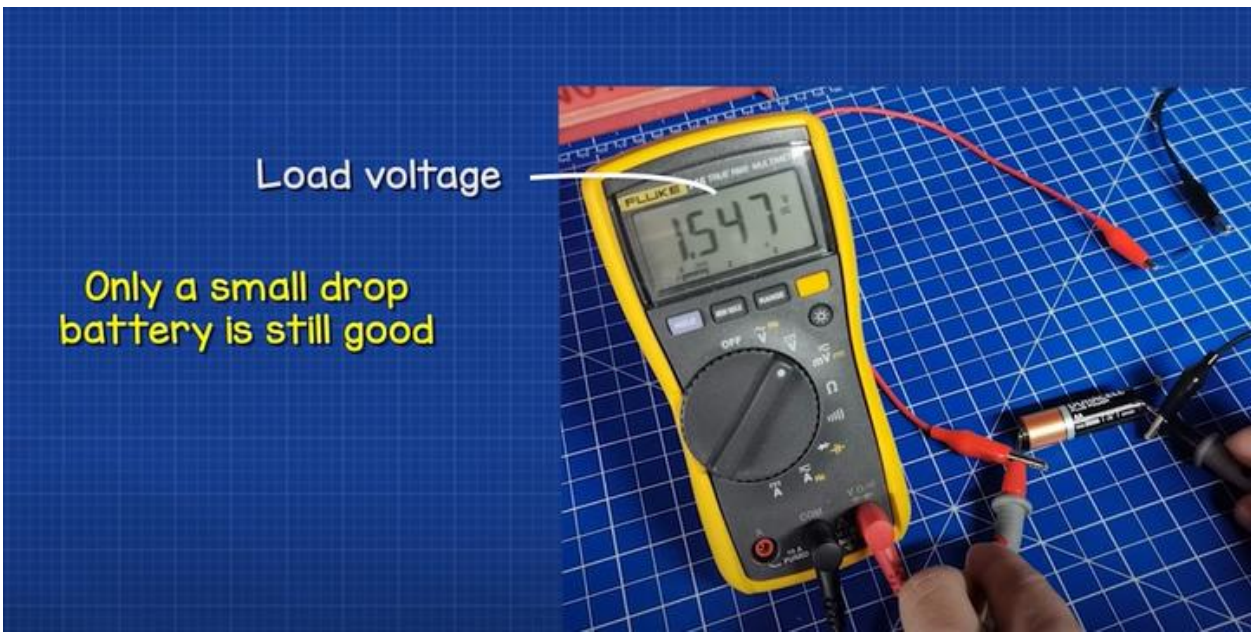
Estimate the life of a battery for a given circuit

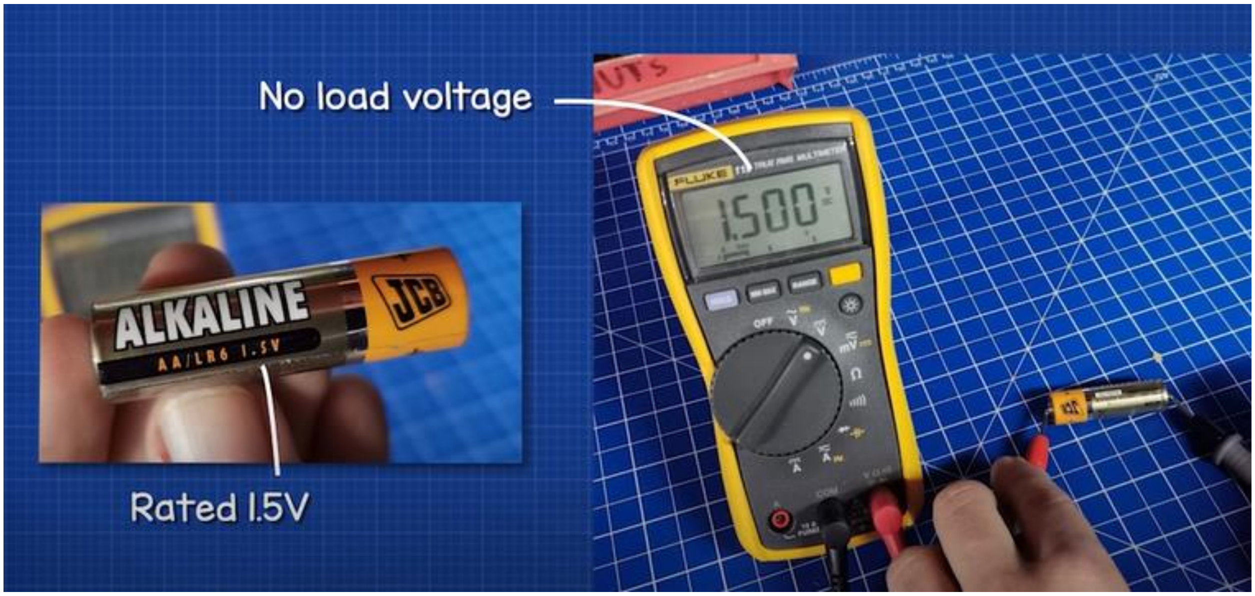
Battery Capacity	3000	mAh
Circuit Current	19	mA
	Calculate	
Battery Life	157.89473684210526	Hours (Maximum)
Battery Life	118.42105263157895	Hours (Likely)

For example:

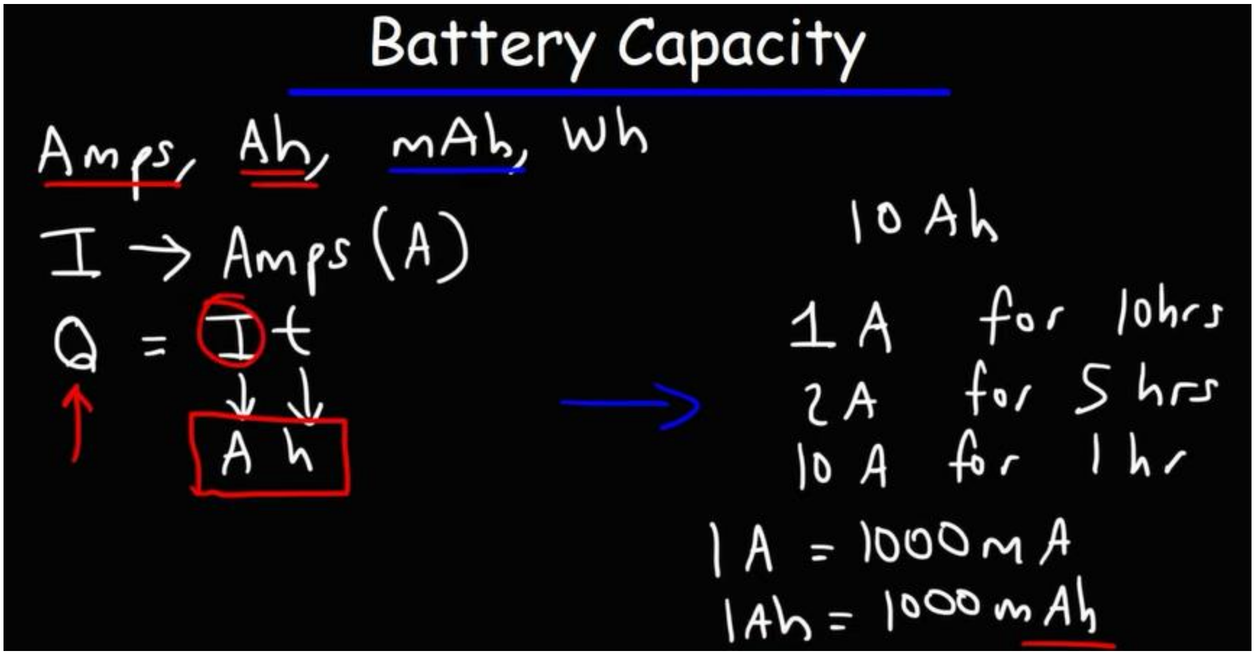


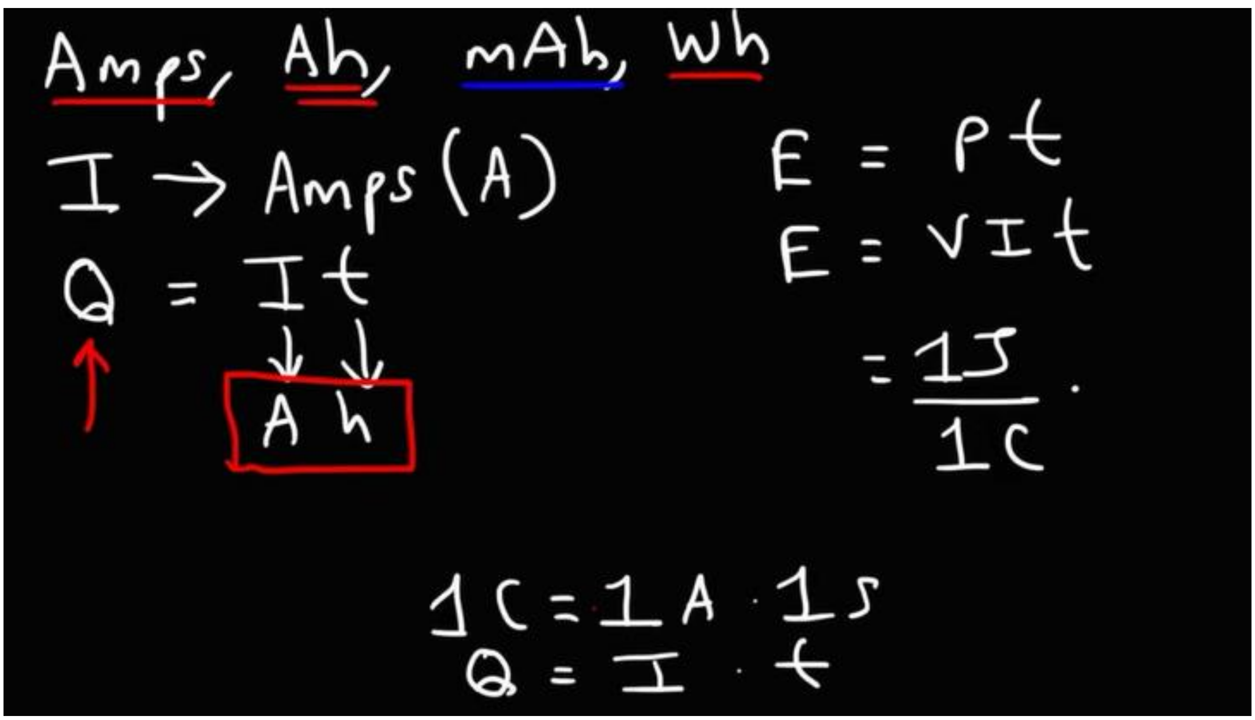

To fully test the battery,
we need to test it under a load condition
If battery is good, we only
see a small voltage drop
1.49V
Current flows
through resistor

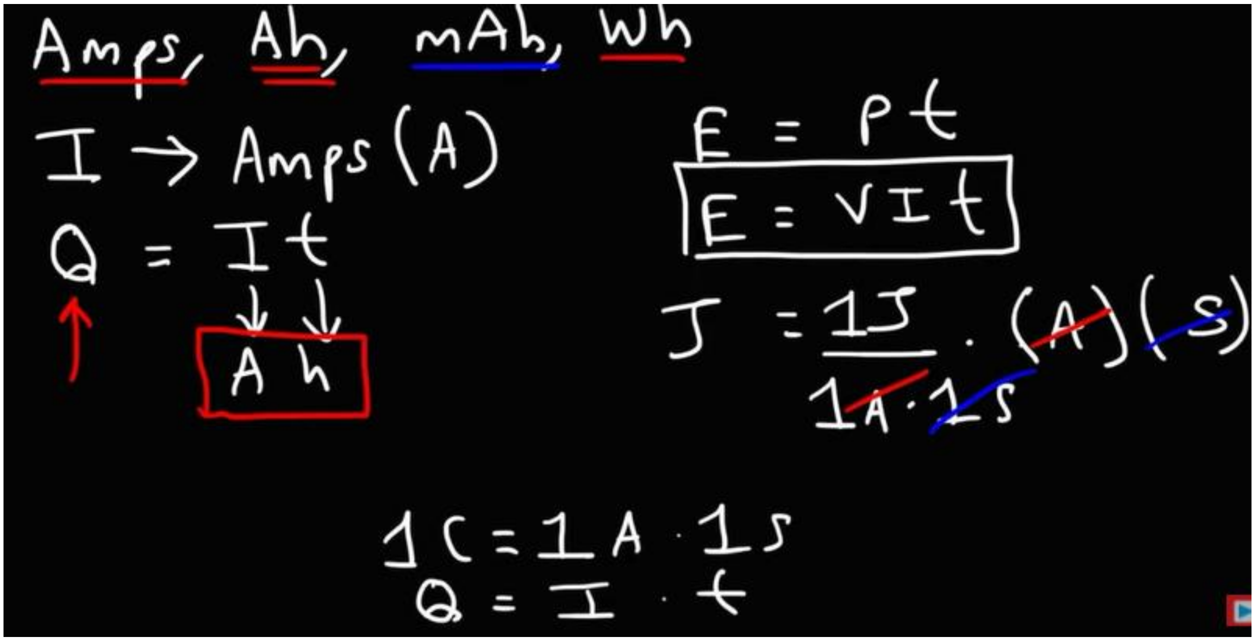

Load voltage
Only a small drop
battery is still good
FLUKE
1.547

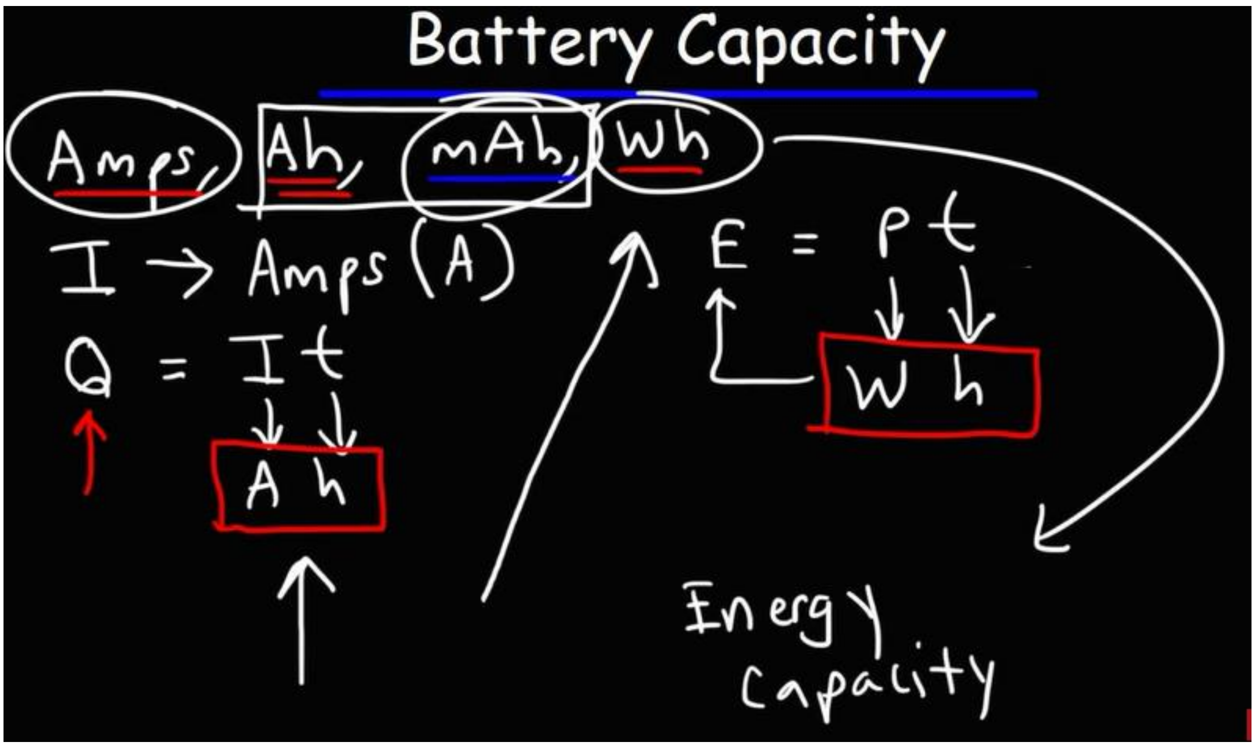


Battery Capacity - Amp-Hours, mAh, and Watt-Hours

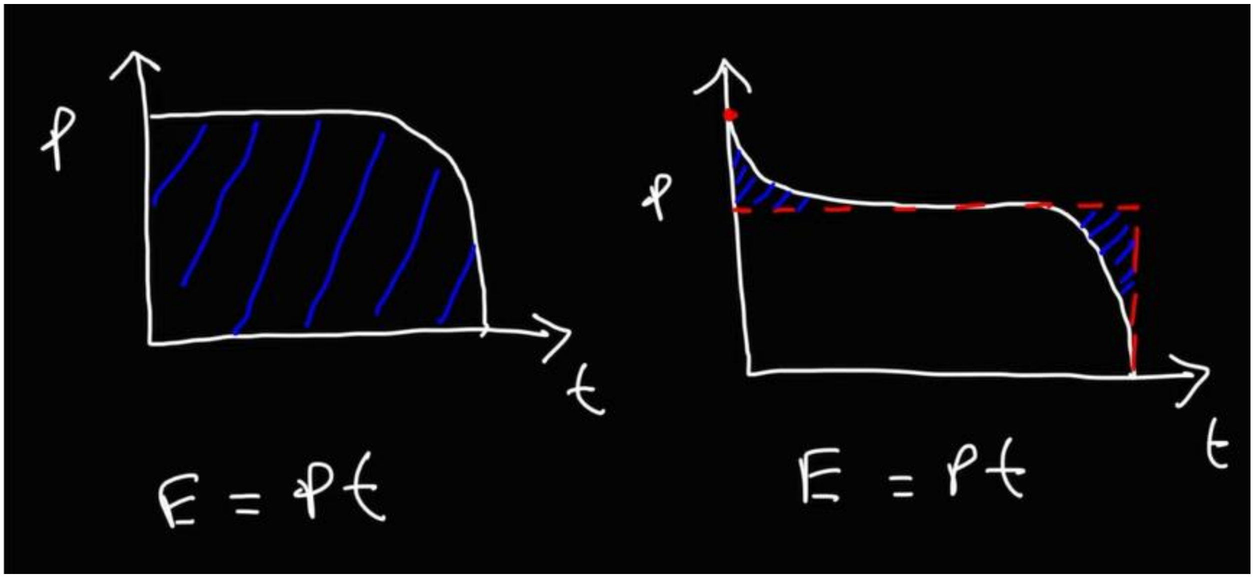

Battery Capacity
Amps, Ah, mAh, Wh
I → Amps (A)
Q = It
A h
10 Ah
1 A for 10hrs
2 A for 5 hrs
10 A for 1 hr
1 A = 1000 mA
1Ah = 1000 mAh

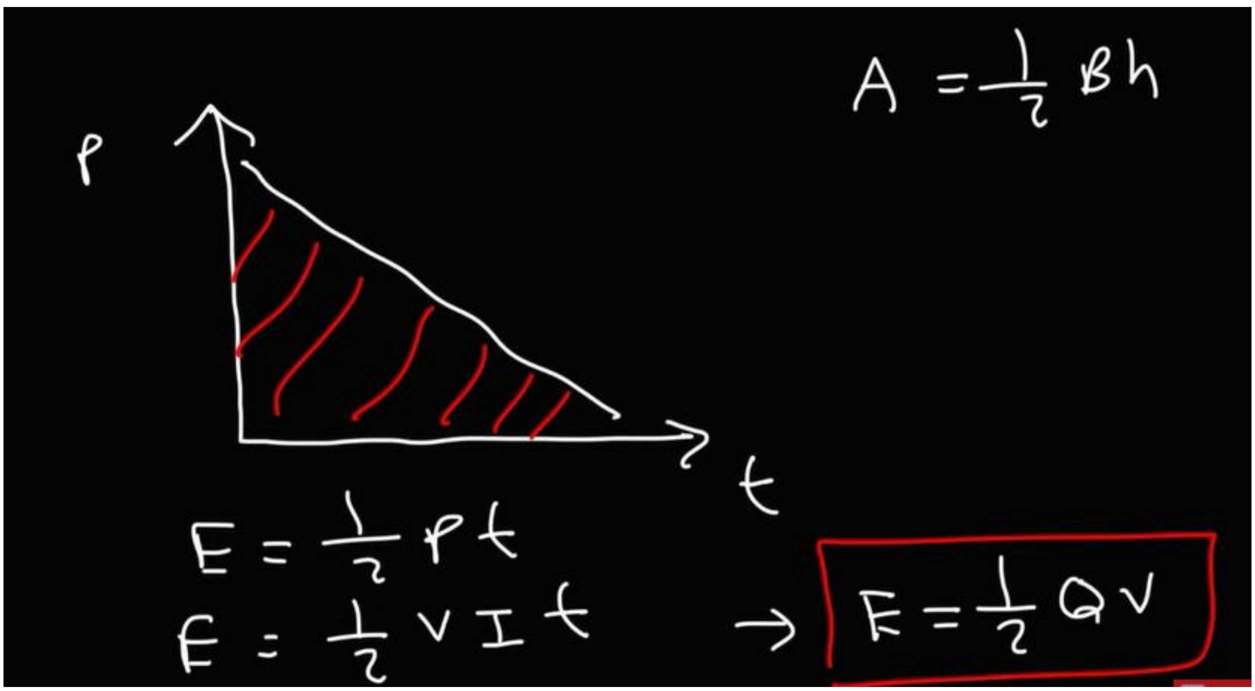

Amps, Ah, mAh, Wh
I → Amps (A)
Q = It
A h
E = Pt
E = VIt
= 1J / 1C
1C = 1 A · 1 s
Q = I · t



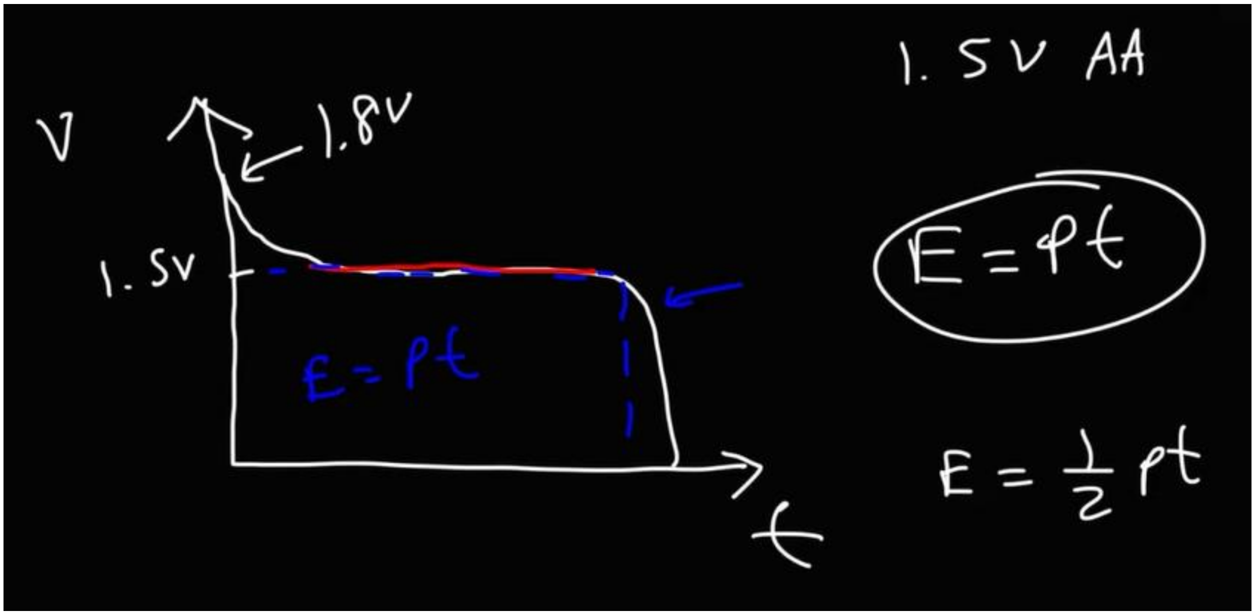


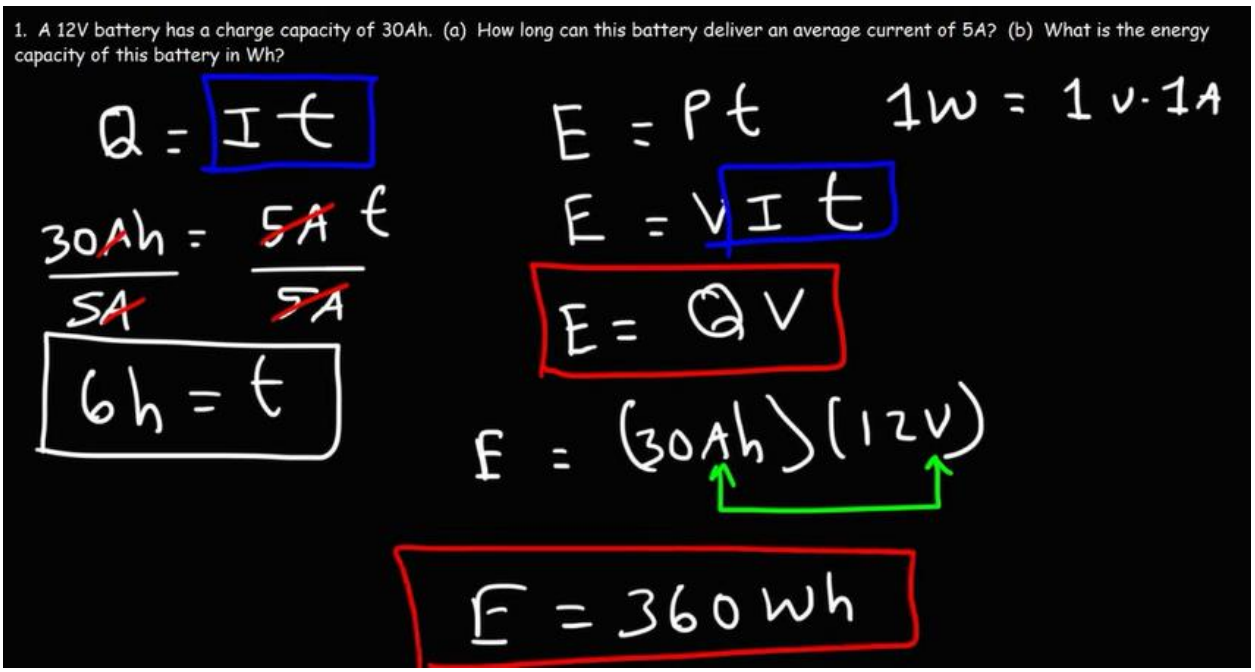
Charge capacity vs energy capacity





For capacitor


1.5V AA
V
1.8V
1.5V
E = Pt
t
E = Pt
E = 1/2 Pt


1. A 12V battery has a charge capacity of 30Ah. (a) How long can this battery deliver an average current of 5A? (b) What is the energy capacity of this battery in Wh?
Q = It
30Ah / 5A = 5A t / 5A
6h = t
E = Pt
1W = 1V·1A
E = VIt
E = QV
E = (30Ah)(12V)
E = 360Wh

2. A 6V battery has an energy capacity of 300Wh. (a) What is the charge capacity of this battery? (b) What is the average current that this battery can deliver if it's used continuously for 25 hours?

$$E = QV$$

$$300\,Wh = Q(6V)$$

$$\frac{300\,VAh}{6V} = \frac{Q(6V)}{6V}$$

$$50\,Ah = Q$$

$$P = VI$$

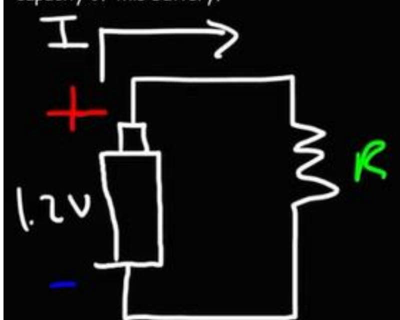
$$1W = 1V \cdot 1A$$

$$Q = It$$

$$\frac{50\,Ah}{25h} = \frac{I(25h)}{25h}$$

$$2A = I$$

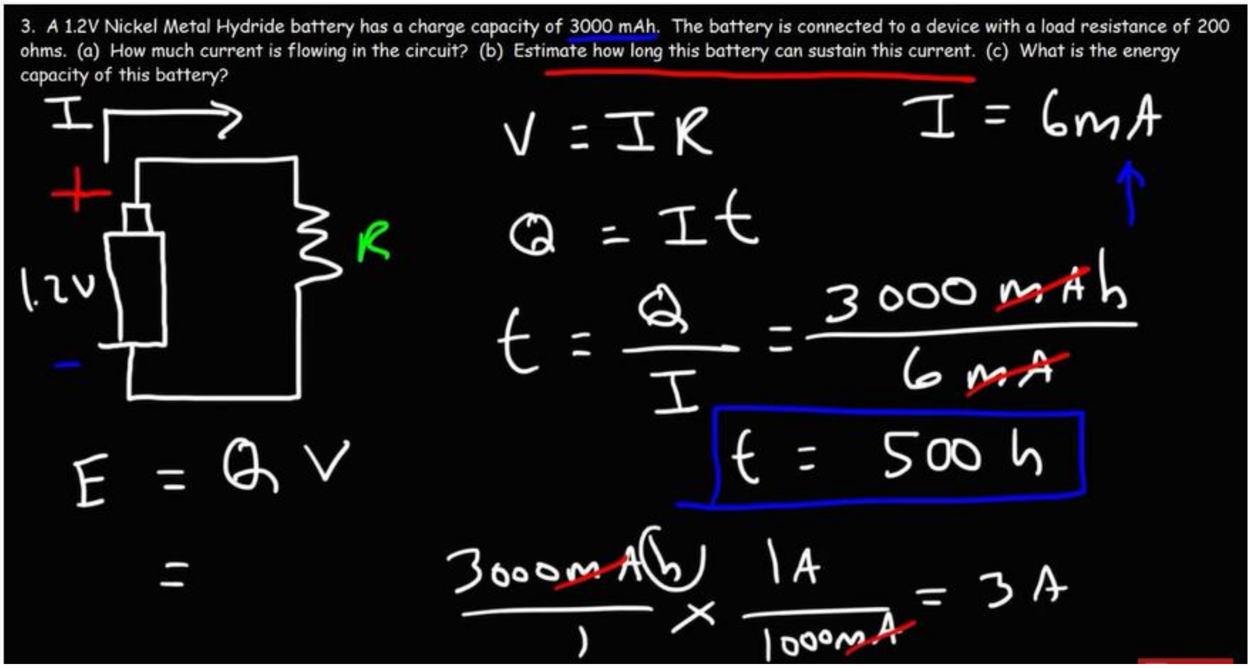
3. A 1.2V Nickel Metal Hydride battery has a charge capacity of 3000 mAh. The battery is connected to a device with a load resistance of 200 ohms. (a) How much current is flowing in the circuit? (b) Estimate how long this battery can sustain this current. (c) What is the energy capacity of this battery?

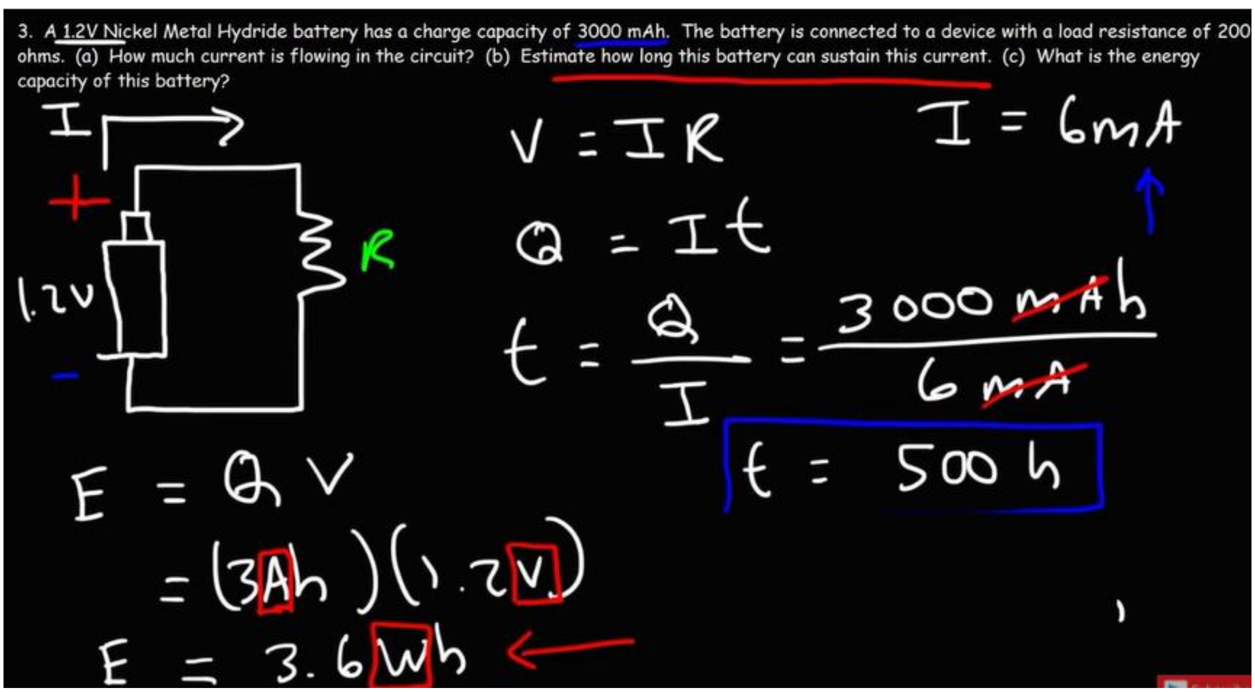


$$V = IR \qquad I = 6mA$$

$$1.2 = I(200)$$

$$I = \frac{0.006\,A}{1} \times \frac{1000\,mA}{1A}$$


3. A 1.2V Nickel Metal Hydride battery has a charge capacity of 3000 mAh. The battery is connected to a device with a load resistance of 200 ohms. (a) How much current is flowing in the circuit? (b) Estimate how long this battery can sustain this current. (c) What is the energy capacity of this battery?
I
R
1.2V
V = IR
I = 6mA
Q = It
t = Q/I = 3000 mAh / 6 mA
t = 500 h
E = QV
=
3000mAh/1 × 1A/1000mA = 3 A


3. A 1.2V Nickel Metal Hydride battery has a charge capacity of 3000 mAh. The battery is connected to a device with a load resistance of 200 ohms. (a) How much current is flowing in the circuit? (b) Estimate how long this battery can sustain this current. (c) What is the energy capacity of this battery?
I
R
1.2V
V = IR
I = 6mA
Q = It
t = Q/I = 3000 mAh / 6 mA
t = 500 h
E = QV
= (3Ah)(1.2V)
E = 3.6Wh

$$V = IR$$

$$P = VI$$

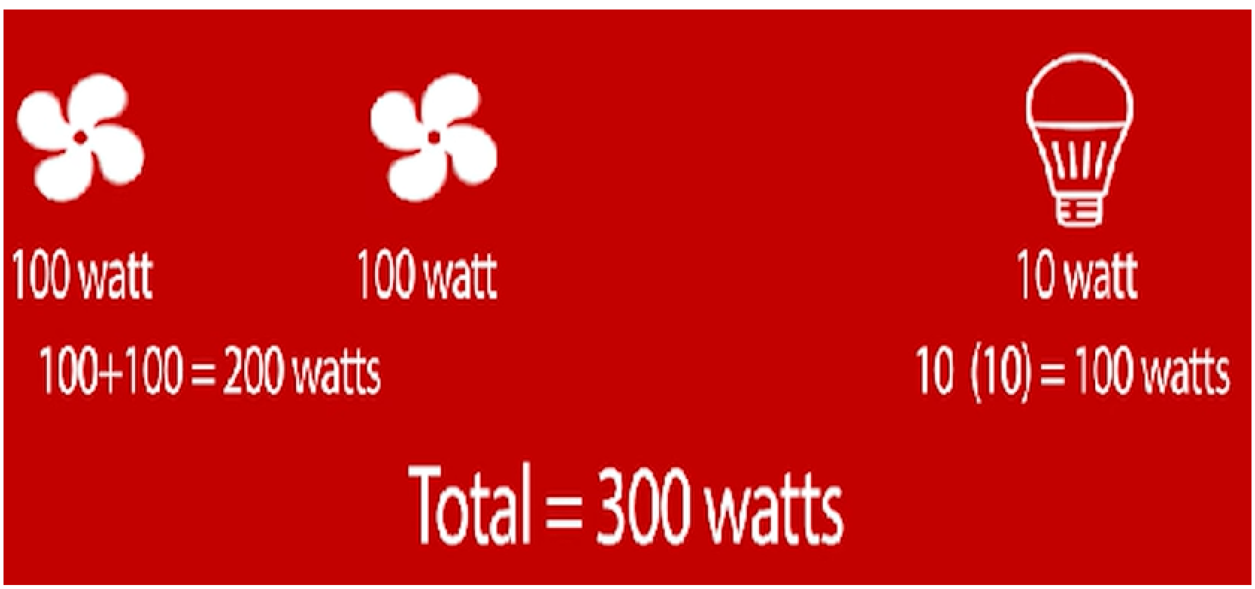
$$Q = It \quad (A \cdot h)$$

$$E = QV \quad (Wh)$$

$$E = Pt$$

$$E = VIt$$

How to check Amperes in Battery



$P = V \times I \times \cos\theta$

$\cos\theta = 1$ (Power factor)

$P = V \times I \times \cos\theta$

$\cos\theta = 1$ (Power factor)

$P = 300$ $V = 220$

$I = ?$

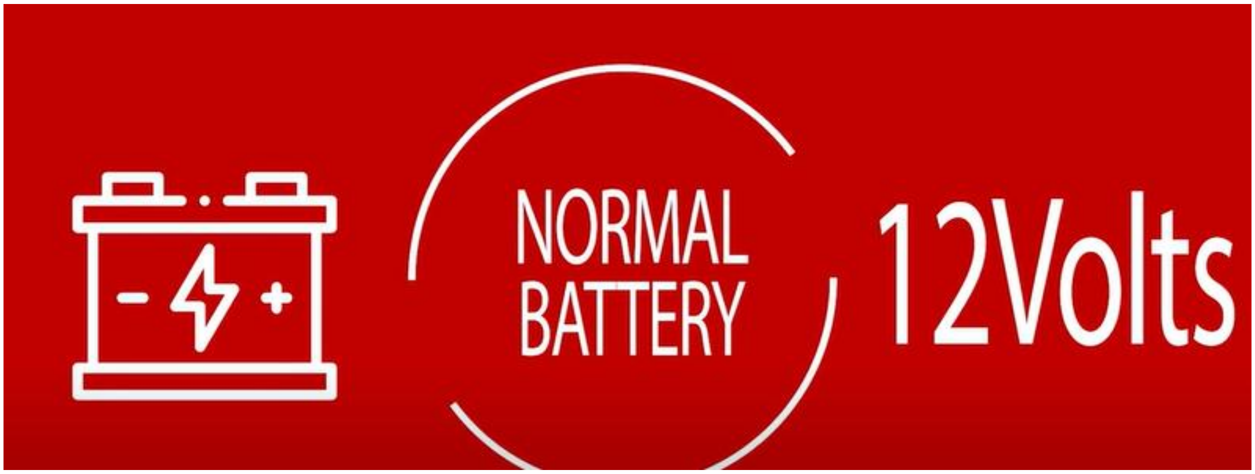
$P = V I \times \cos\theta$

$I = P/V \times 1$

$I = 300/220$

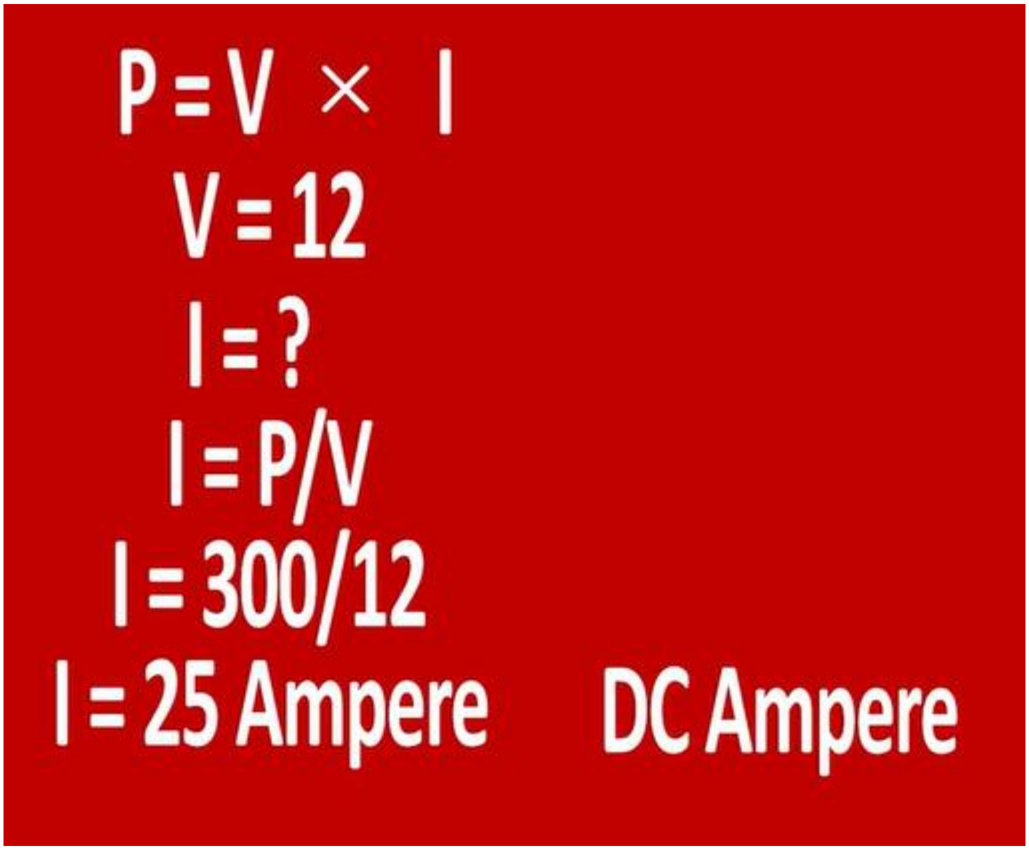
$I = 1.36$ AC Ampere

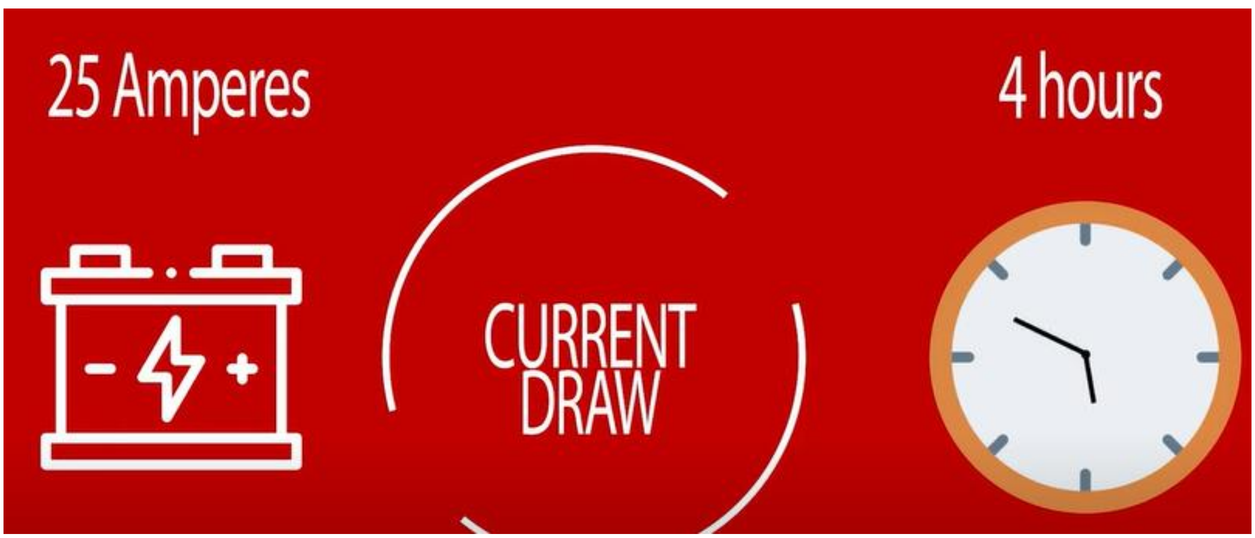
We have to convert AC Amperes into DC Amperes


NORMAL
BATTERY
12Volts

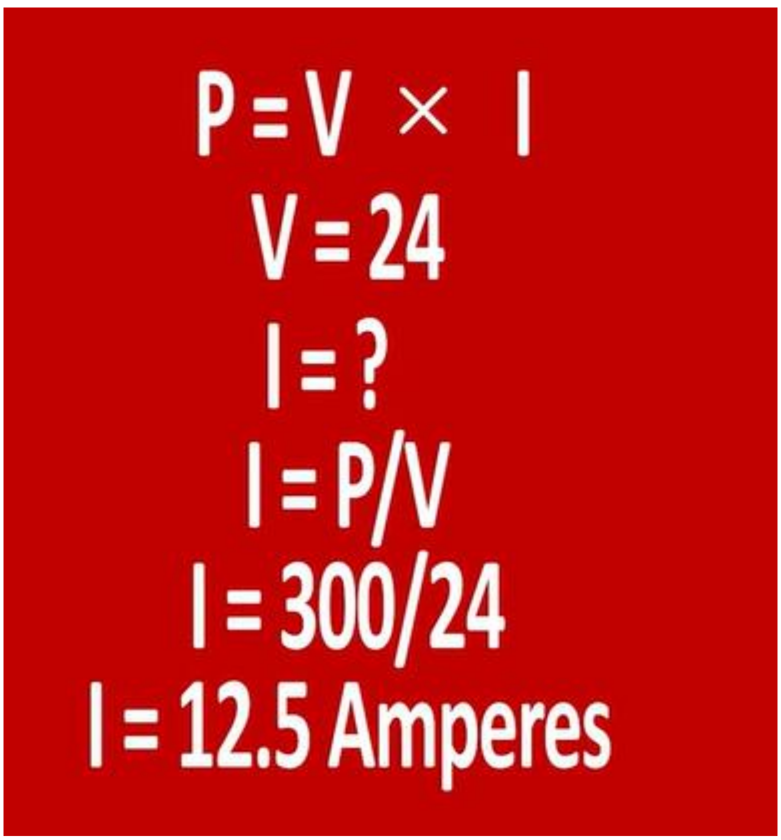

LARGE
SYSTEM
24Volt


5KVA/10KVA
SYSTEM
48Volt


P = V × I
V = 12
I = ?
I = P/V
I = 300/12
I = 25 Ampere
DC Ampere


25 Amperes
4 hours
CURRENT
DRAW


100
Amperes
4 hours


P = V × I
V = 24
I = ?
I = P/V
I = 300/24
I = 12.5 Amperes

$$P = V \times I$$

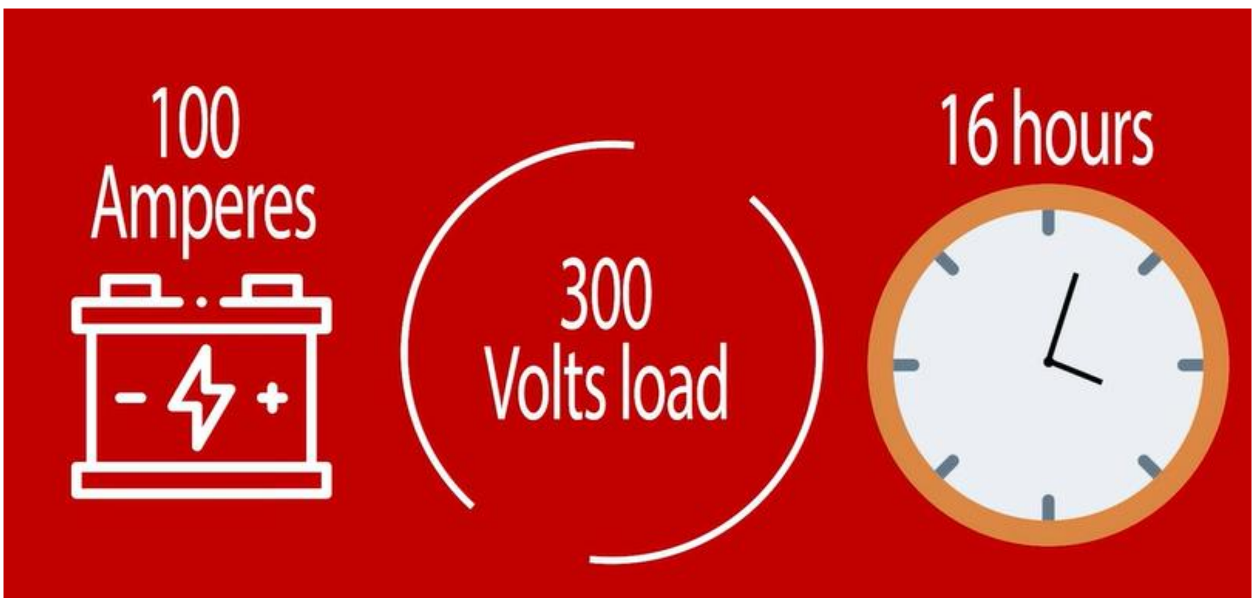
$$V = 48$$

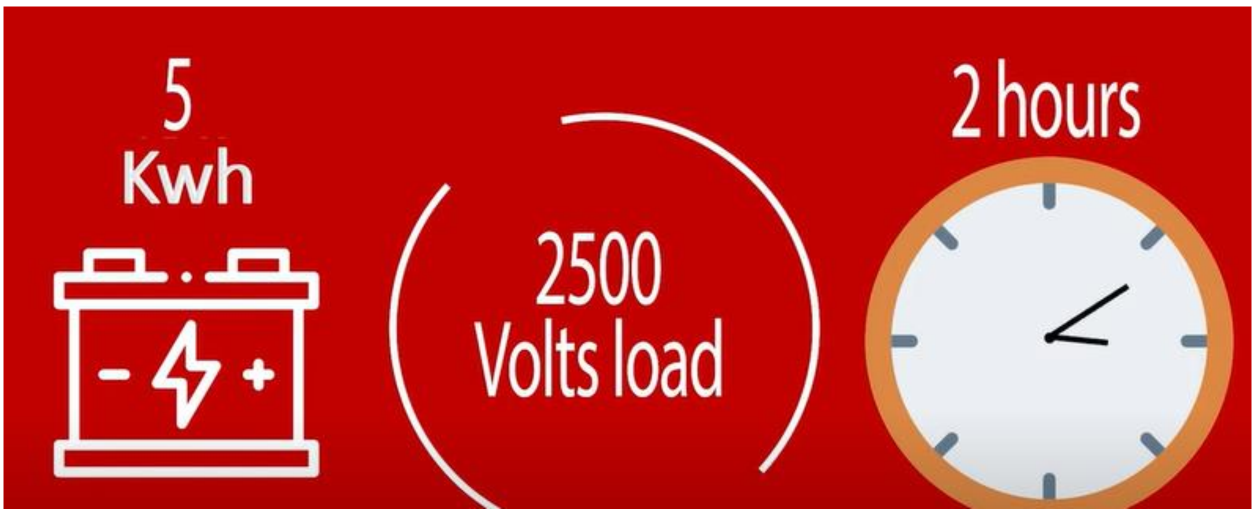
$$I = ?$$

$$I = P/V$$

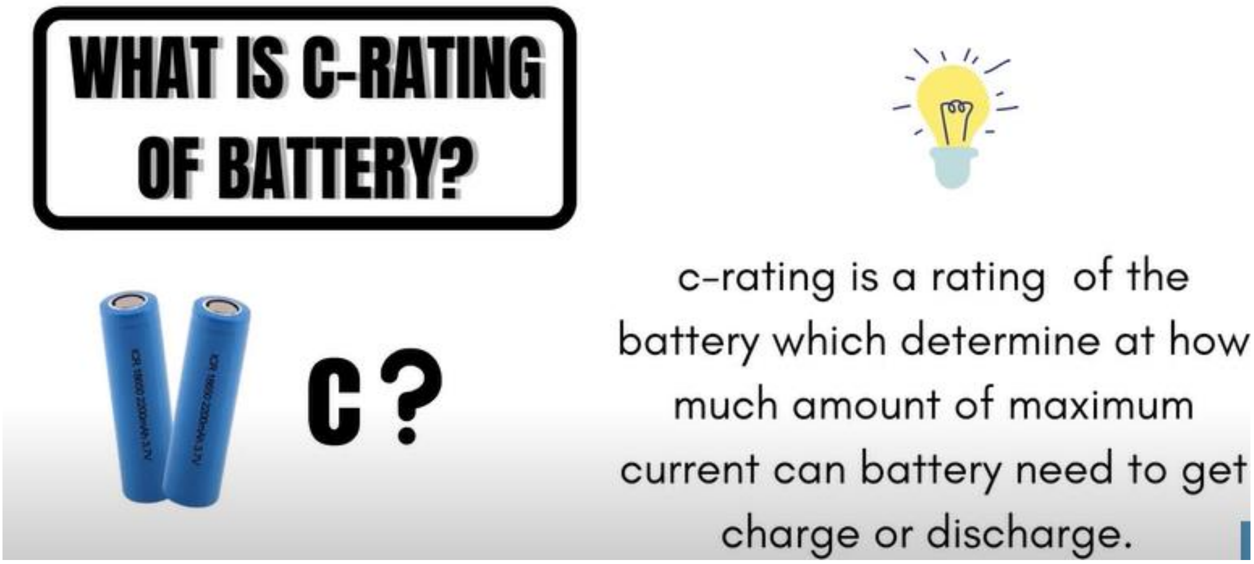
$$I = 300/48$$

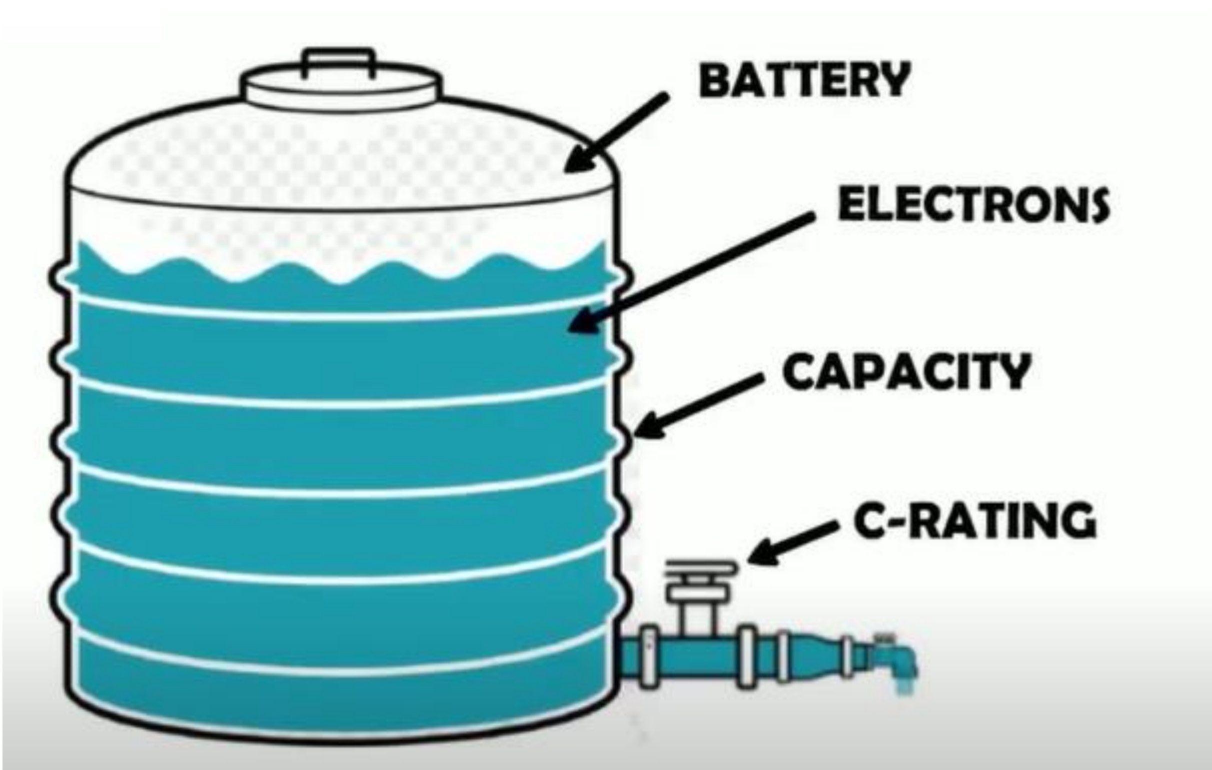
$$I = 6.25 \text{ Amperes}$$

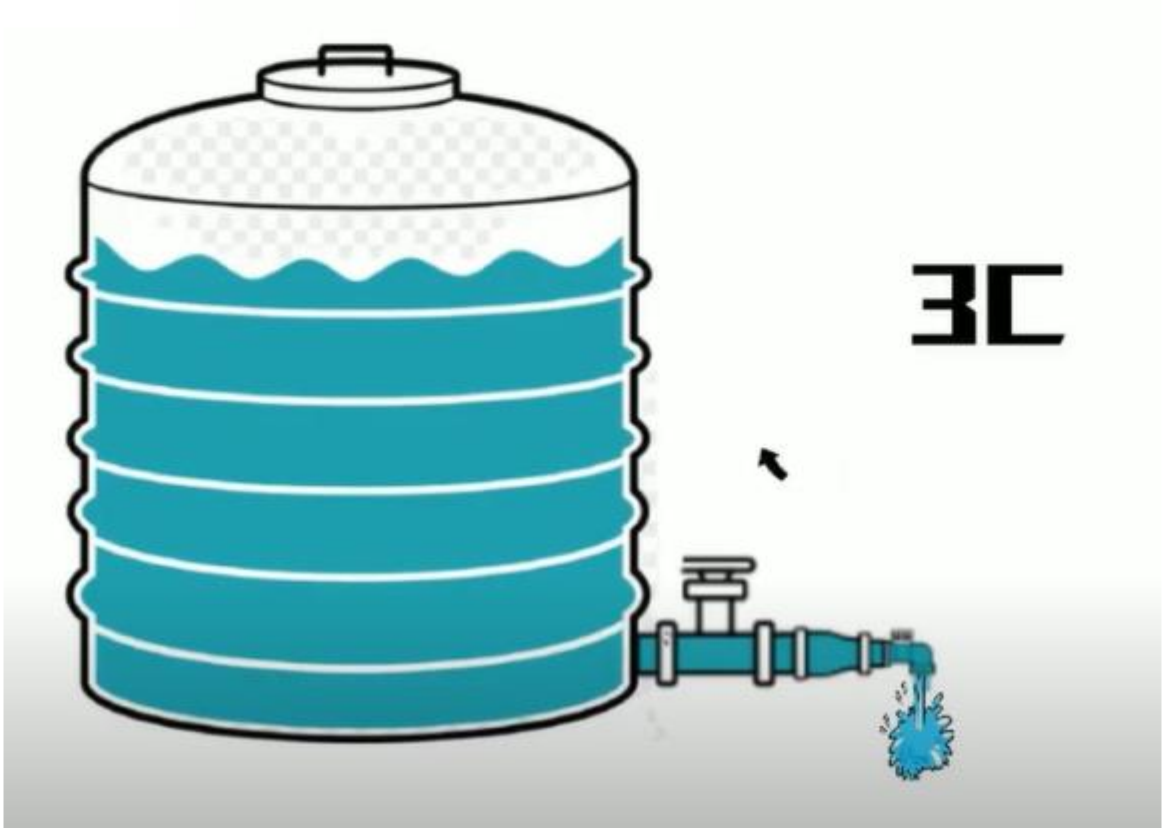


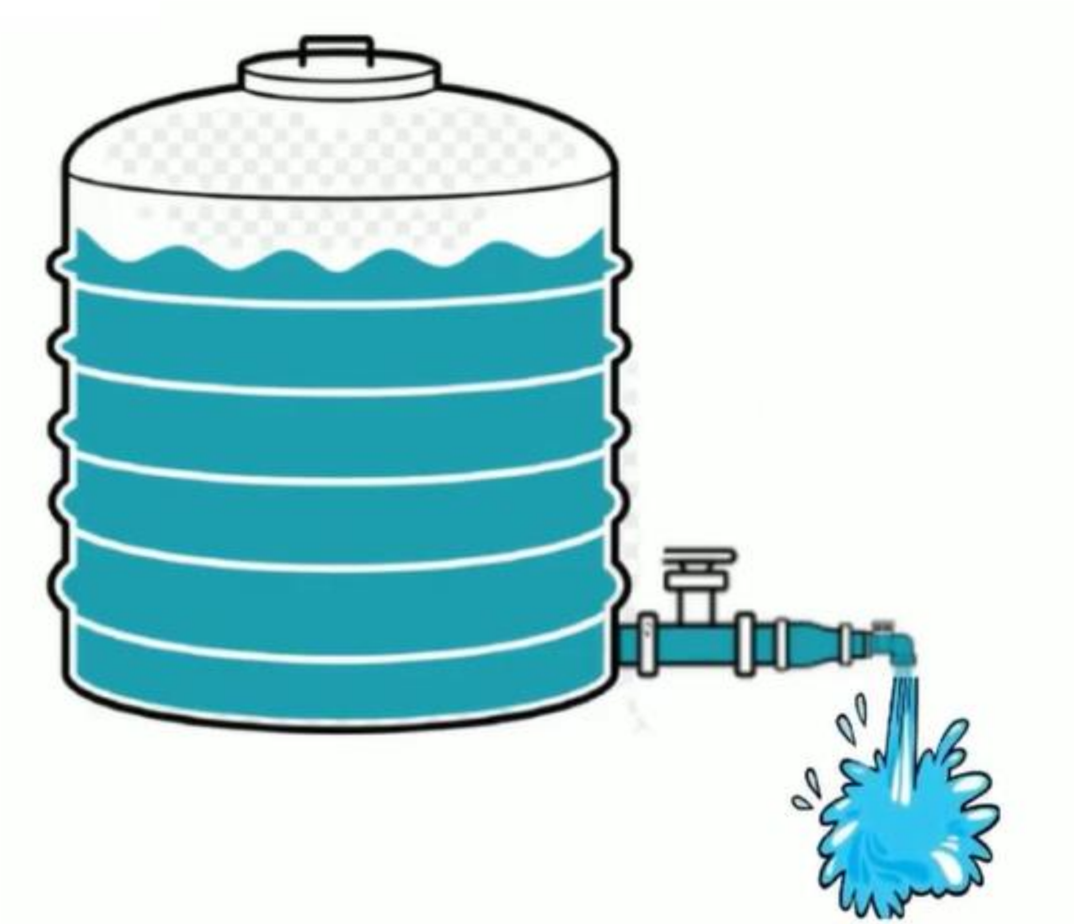


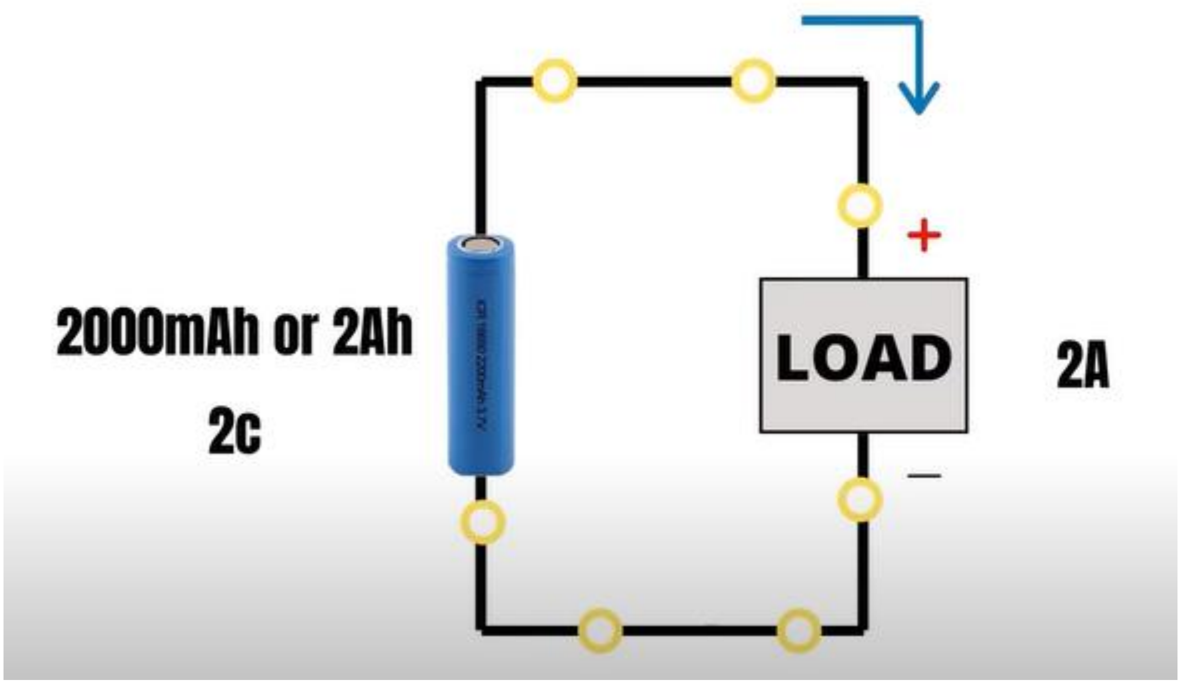
What Is C Rating ?| Lithium Ion Battery & Lipo Battery


WHAT IS C-RATING OF BATTERY?
C ?
c-rating is a rating of the battery which determine at how much amount of maximum current can battery need to get charge or discharge.

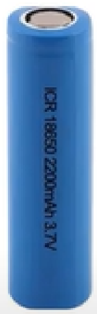

BATTERY
ELECTRONS
CAPACITY
C-RATING


3C




2000mAh or 2Ah
2c
LOAD
2A
+
–

2000mAh or 2Ah



2c = 4 A

maximum current discharge

LOAD = 2A

operating curent

1. discharging rate of battery can be various or more than estimated c-rating.

2. c- rating is defined as maximum current discharging rate of battery

3. battery must discharge below it's c-rating. if battery start discharging above its c-rating, then it will start losing its capacity over time

4. due to over current discharging, the chemistry whithin battery may damage which affect battery cycles

THERE ARE DIFFERENT C-RATINGS FOR DIFFERENT BATTERIES

REPRESENT AS:

0.5C, 1C, 2C, 10C, 20C, 25C, 30C, 40C

OR

2C, C_1, C_2, C_{10}, C_{20}, C_{25}, C_{30}, C_{40}

WE CAN SEE IN IMAGES C-RATINGS OF BATTRIES

CALCULATION FOR CALCULATING MAXIMUM DISCHARGING CURRENT OF THE BATTERY

A BATTERY HAVING CURRENT CAPACITY OF 4000mAh AND HAVING C-RATING OF 10C THEN HOW MUCH MAX. CURRENT BATTERY CAN DELIVER?

FIRST CONVERT 4000mAh INTO AMPS (A) ,

$$4000\text{mAh} \times 10^{-3} = 4\text{Ah}$$

$$10C = 10 \times 4 = \mathbf{40\ A}$$

(THIS **40 Ampere** IS THE **MAXIMUM DISCHARGING CURRENT** OF THE BATTERY)

BATTERY HAVING CURRENT CAPACITY OF 5000mAh & C-RATING IS 20C

FIRST CONVERT 5000mAh INTO AMPS (A) ,

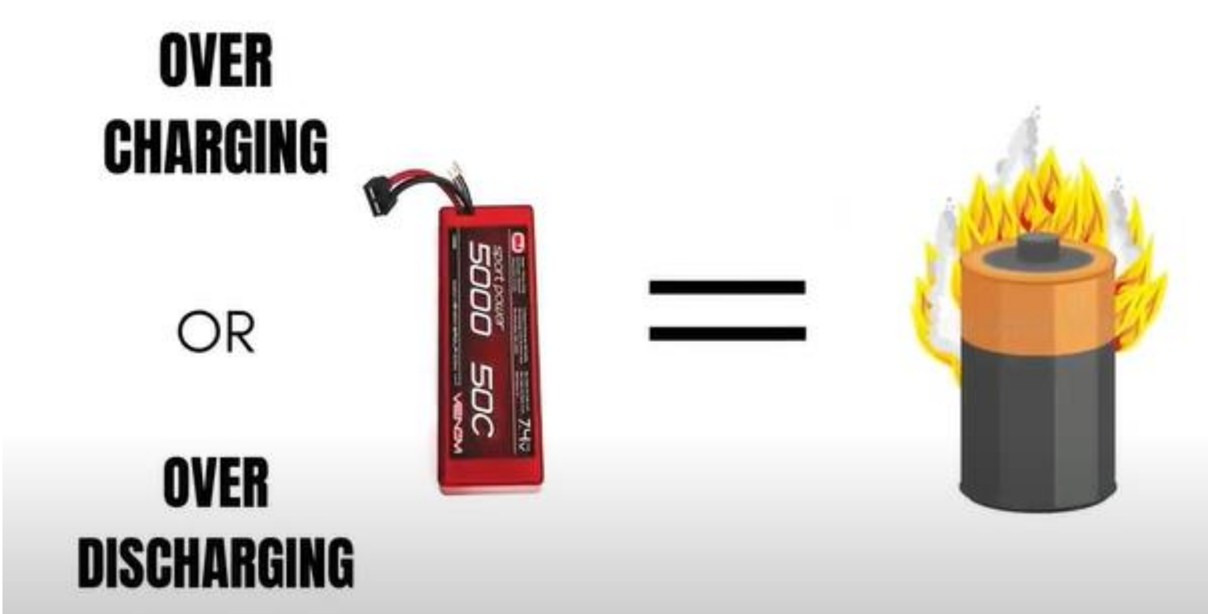
$$5000\text{mAh} \times 10^{-3} = 5\text{Ah}$$

$$20C = 20 \times 5$$

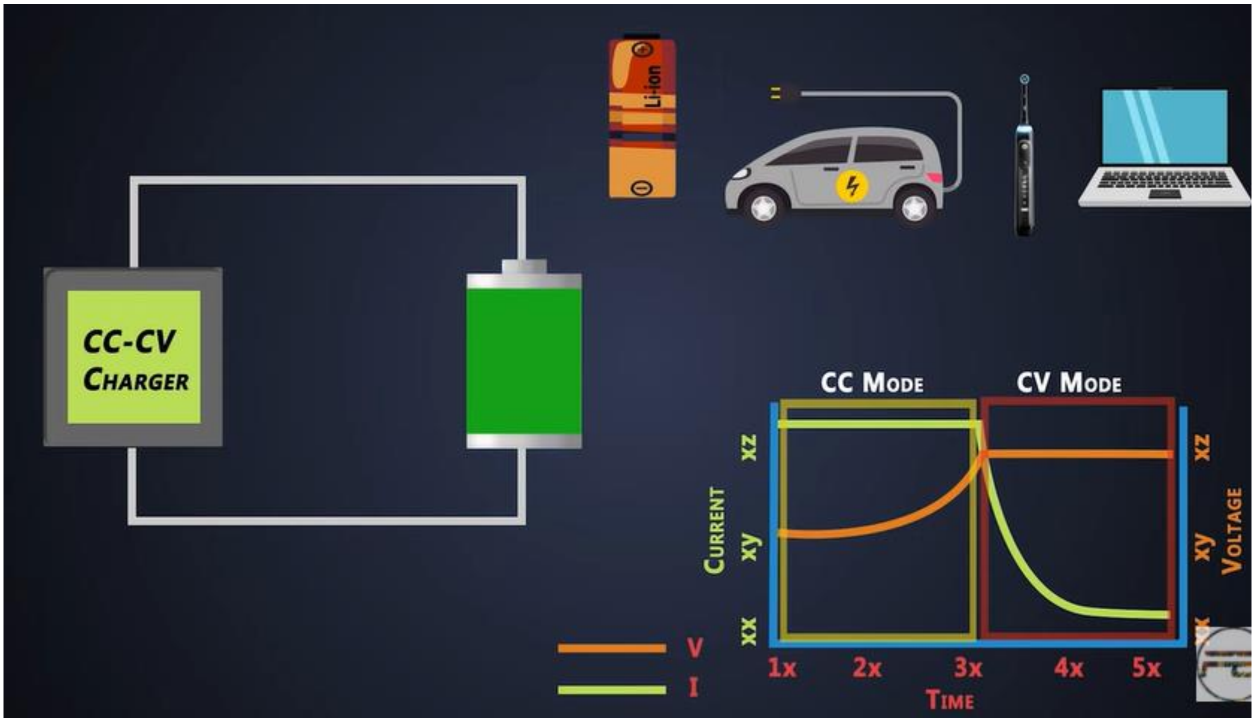
$$= \mathbf{100\ Amps}$$

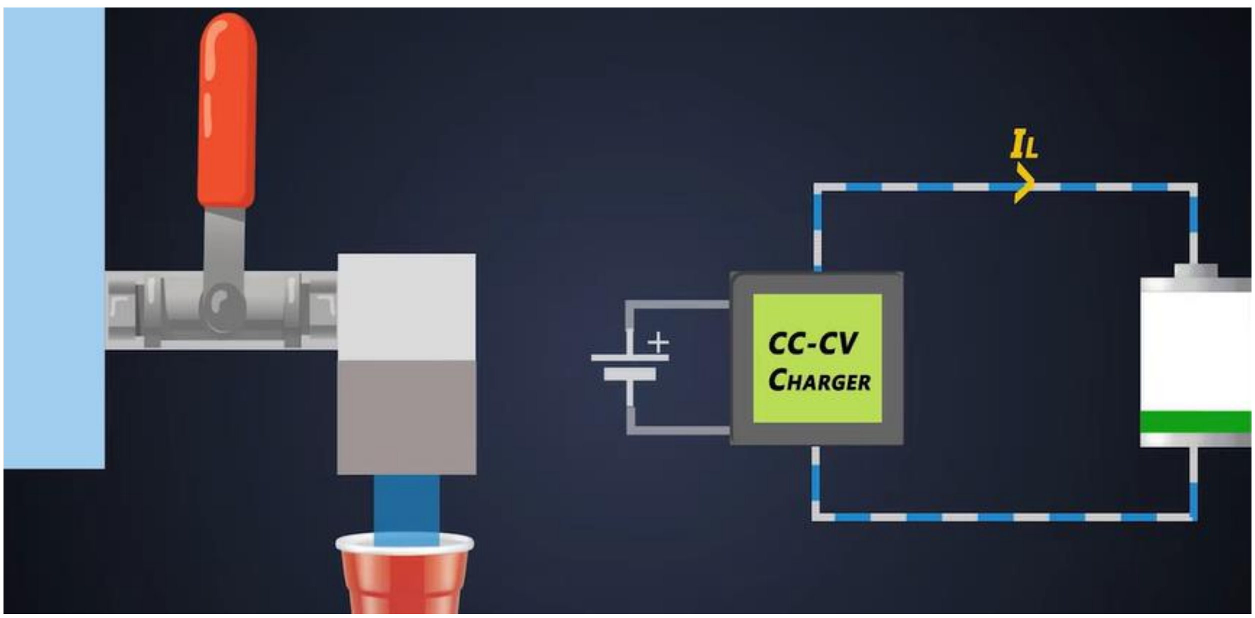
(THIS **100 Ampere** IS THE **MAXIMUM DISCHARGING CURRENT** OF THE BATTERY)

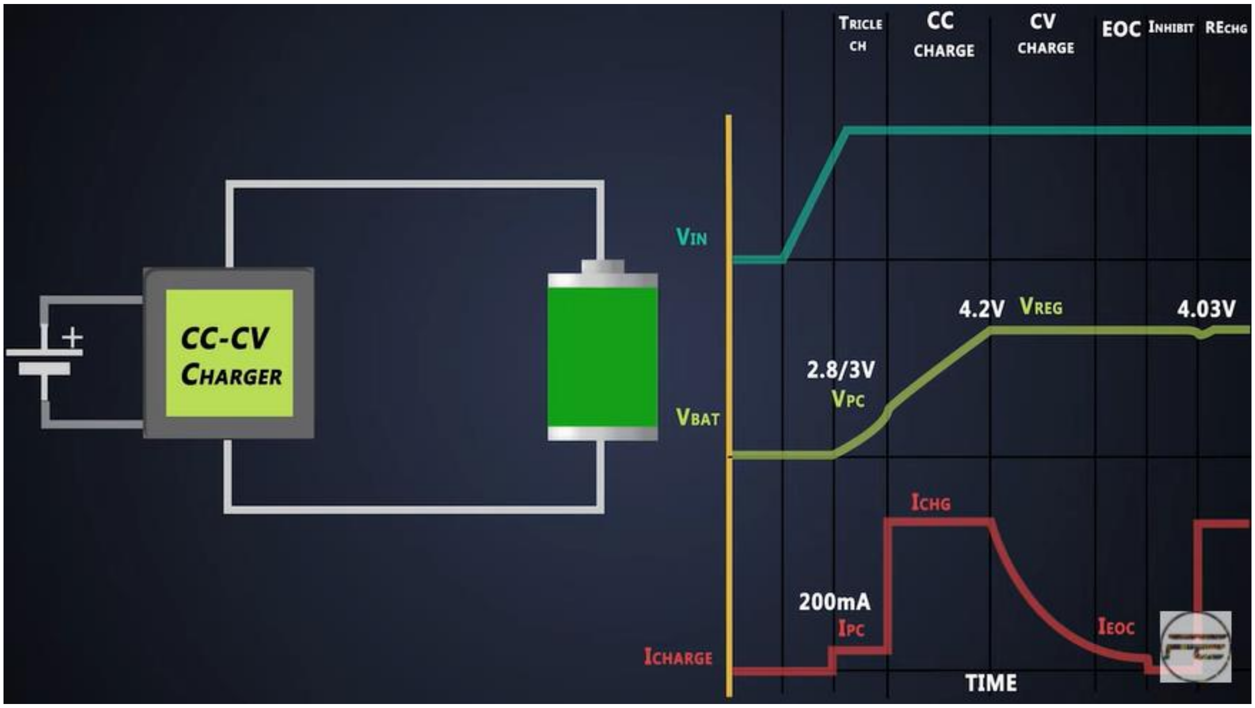

ORANGE
SMARTLY FLAVOURED LIPO BATTERY
2000
mAh
MATCHED
TRUE BALANCE
1Cell 3.7V
30C
Battery Capacity (mAh)
No. of cells & Voltage
C Rating


OVER CHARGING
OR
OVER DISCHARGING
5000 50C
sport power
VENOM
7.4V

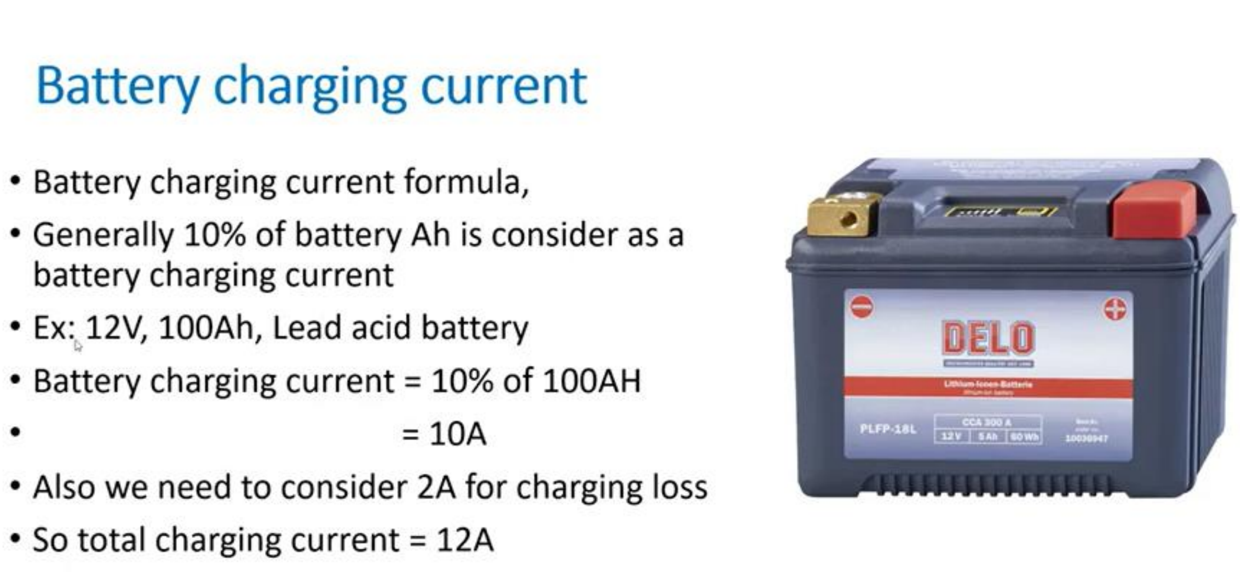
How does a Li-ion Battery Charger work?


Li-ion
CC-CV
Charger
CC Mode
CV Mode
Current
Voltage
xz
xy
xx
V
I
1x
2x
3x
4x
5x
Time


I_L
CC-CV
Charger



How to calculate Battery charging current



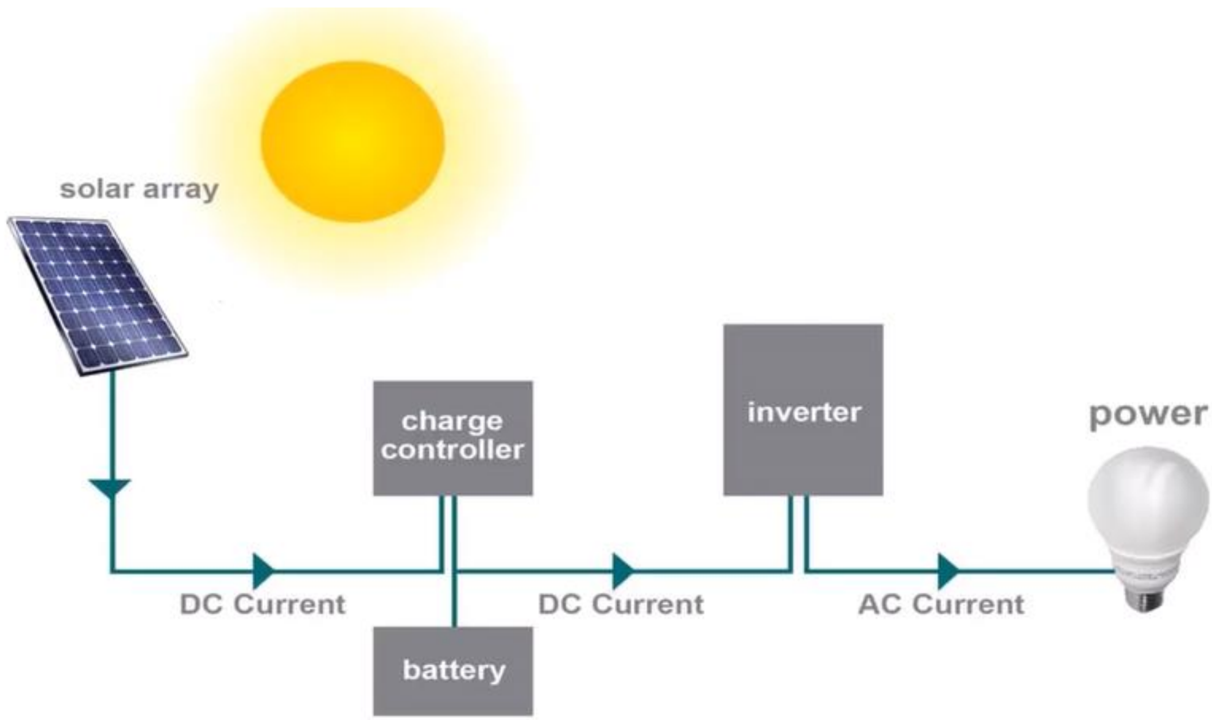
Battery charging time

- Battery charging time formula,
- T = battery Ah/ charging current
- T= Ah / A
- EX: 12V,100Ah battery
- T=100/12
- T=8.3hours
- But we need to consider battery losses 40%
- So total battery Ah = 120+40 = 160Ah
- Total charging time required = 160/12 = 13.3Hr

Battery discharging current

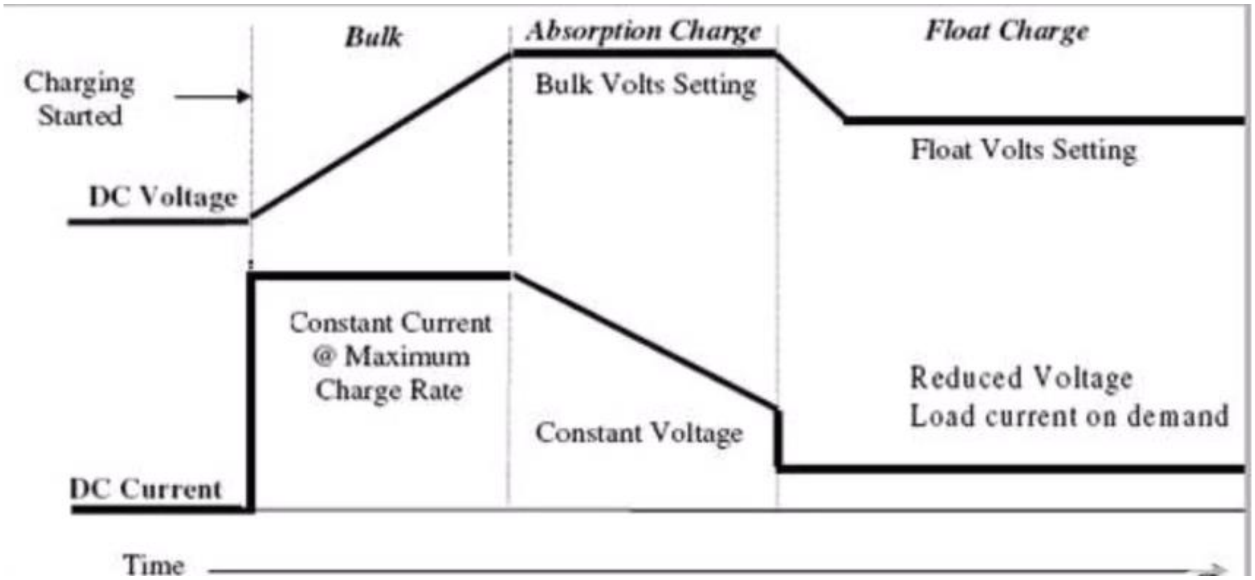
- Battery discharging current formula,
- Generally 10% of battery Ah is consider as a battery discharging current
- Ex: 12V, 100Ah, Lead acid battery
- Battery discharging current = 10% of 100AH
- = 10A
- So total discharging current = 10A
- So 100Ah battery can discharge their full current about 10hours time

MPPT Charge Controllers



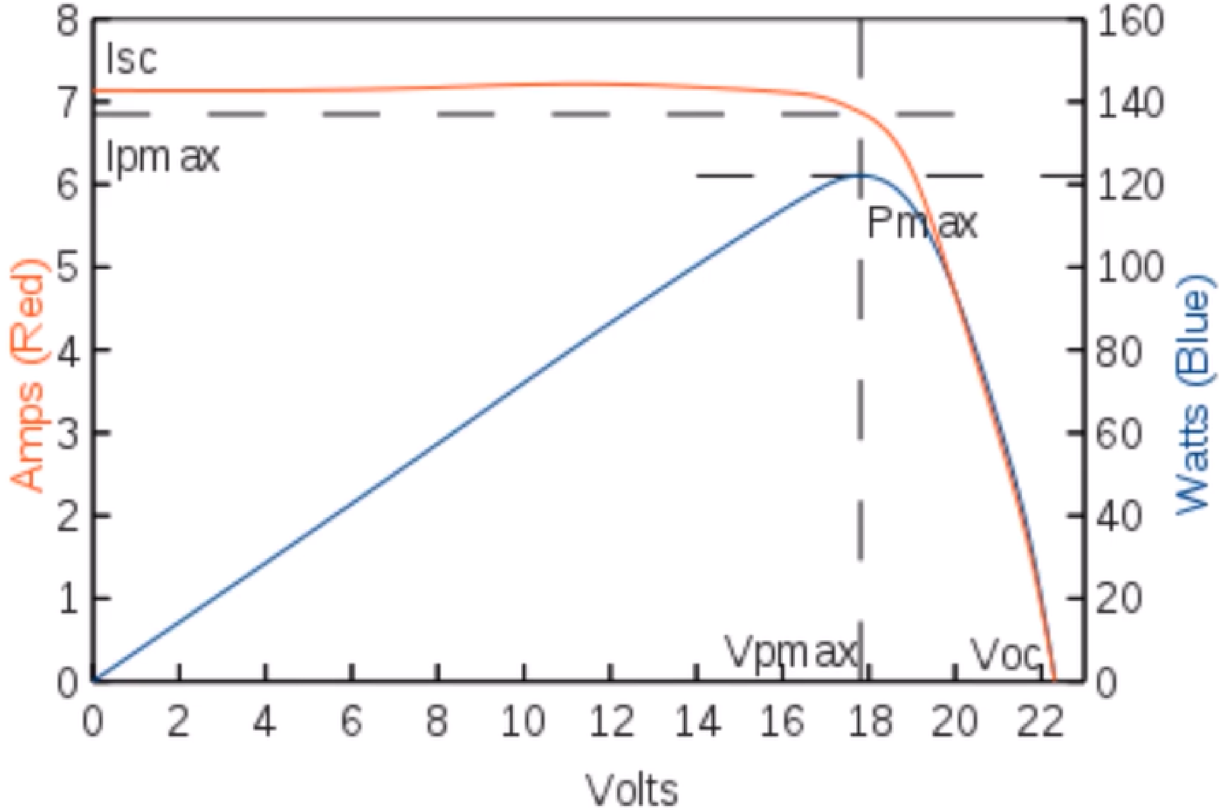
1. Simple on/off controller

2. PWM controller


Bulk
Absorption Charge
Float Charge
Charging Started
Bulk Volts Setting
Float Volts Setting
DC Voltage
Constant Current
@ Maximum
Charge Rate
Reduced Voltage
Load current on demand
Constant Voltage
DC Current
Time

3. MPPT

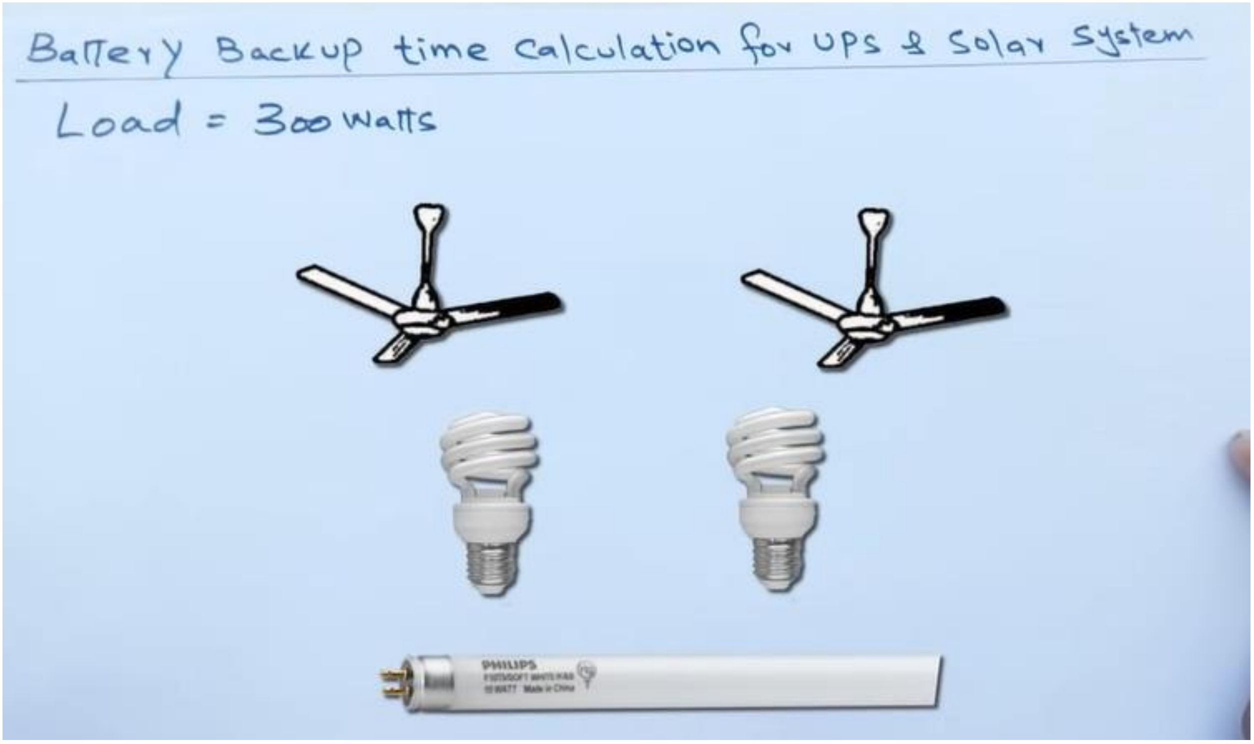

MidNite
CLASS

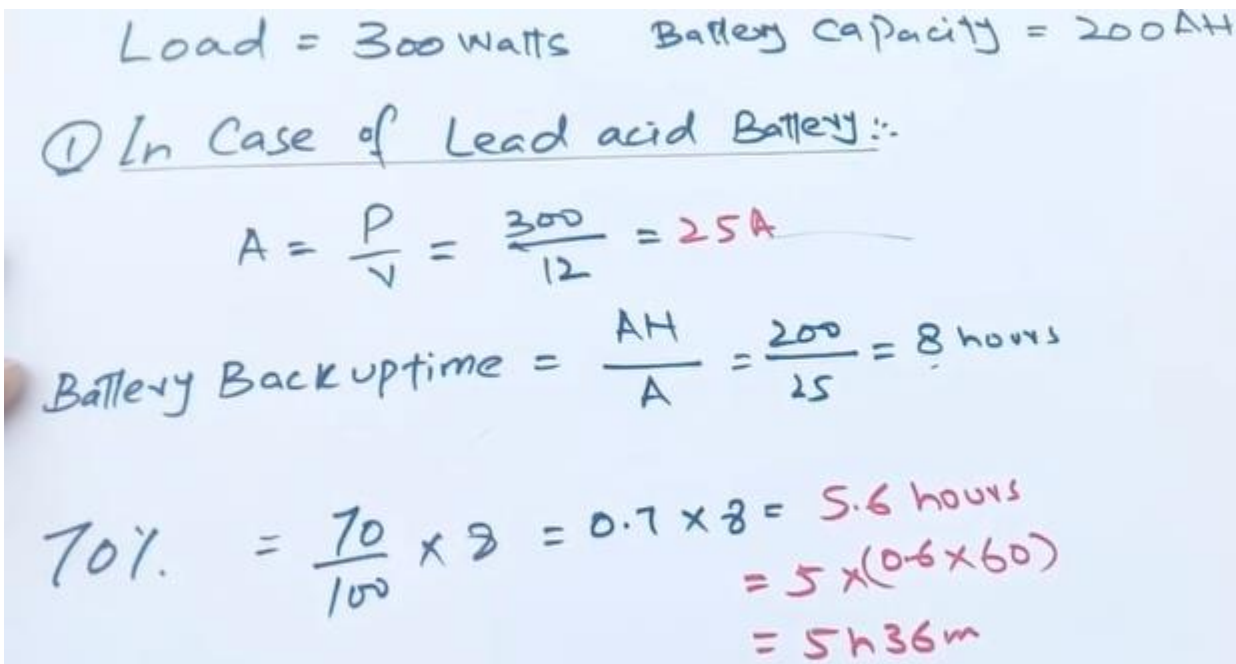


Isc
Ipmax
Pmax
Vpmax
Voc
Amps (Red)
Watts (Blue)
Volts
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120
140
160
0 2 4 6 8 10 12 14 16 18 20 22

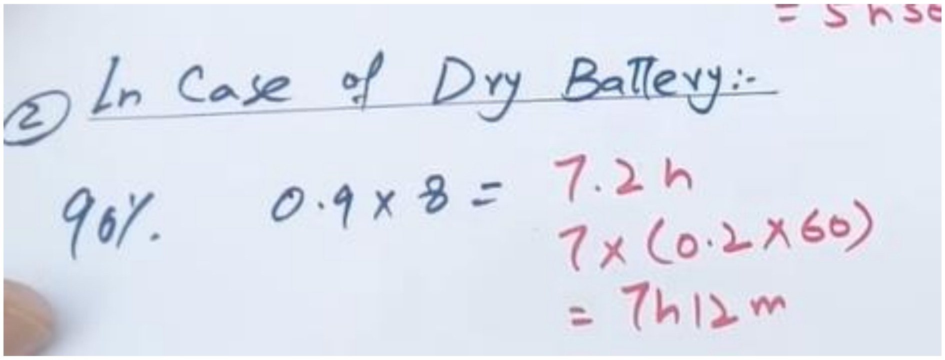

RENOGY
Module Type:
RNG-50D
Max Power at STC
50 W
Open-Circuit Voltage
22.7 V
Short-Circuit Current
2.84 A
Optimum Operating Voltage
18.5 V
Optimum Operating Current
2.70 A
Temp Coefficient of P
-0.23%/°C
Temp Coefficient of V
-0.33%/°C
Temp Coefficient of I
0.05%/°C
Max System Voltage
600VDC (UL)
Max Series Fuse Rating
15 A
Fire Rating
Class C
Weight
4.5kgs / 9.9lbs
Dimensions
630x541x30mm / 24.8x21.3x1.2in
STC
Irradiance 1000 W/m², T = 25°C, AM=1.5
WARNING: This module produces electricity when exposed to light.
Please follow all applicable electrical safety precautions.
Only qualified personnel should install or perform maintenance work on these modules.
Beware of dangerously high DC voltages when connecting modules.
Do not damage or scratch the rear surface of the module.
Follow your battery manufacturer's recommendation.
CE

Battery backup time calculation for UPS and Solar system


Battery Backup time calculation for UPS & Solar System
Load = 300 watts
PHILIPS


Load = 300 watts Battery Capacity = 200AH
① In Case of Lead acid Battery :-
A = P/V = 300/12 = 25A
Battery Backuptime = AH/A = 200/25 = 8 hours
70% = 70/100 × 8 = 0.7 × 8 = 5.6 hours
= 5 ×(0.6 × 60)
= 5h36m

8V dead



Dry, tubular, gel → deep cycle

Calculating Battery Bank Capacity

1.5V, 1000 mAh (1 A for 1 hour, 2A for half hour, 100mA for 10 hours)

2 cells of 1.5V 2000 mAh each in series: 3V 2000 mAh

4.2V each cell, 2000mAh each cell

4.2V, 3 cell parallel x 2Ah= 6000 mAh

4.2V x 3 series = 12.6 V

2 Ah x 3 parallel = 6 Ah

Total 12.6 V, 6 Ah pack

Wh?

Parallel to increase capacity

Each cell 3.7V x 2Ah=7.4 Wh

17Ah x 8 = 136 Ah x 12V= 1632 Wh = 1.632 kWh

7 cells series x 20 parallel

3.7V each of 7 group

2.5A x 20 parallel= 50A

7 x 3.7V= 25.9V x 50A = 1295 Wh=1.295 kWh

Battery C-rate

2. C-RATE :

⇓

Rate at which the CAPACITY of battery is built up (charged) or given-up (discharged) to load.

$$I_B = \frac{C}{N}$$

- C → capacity Ah
- N → No. of hours of discharge
- I_B → Ave battery current

For a 20 Ah battery and 10 hours discharge

$$I_B = \frac{20Ah}{10h} = 2A$$

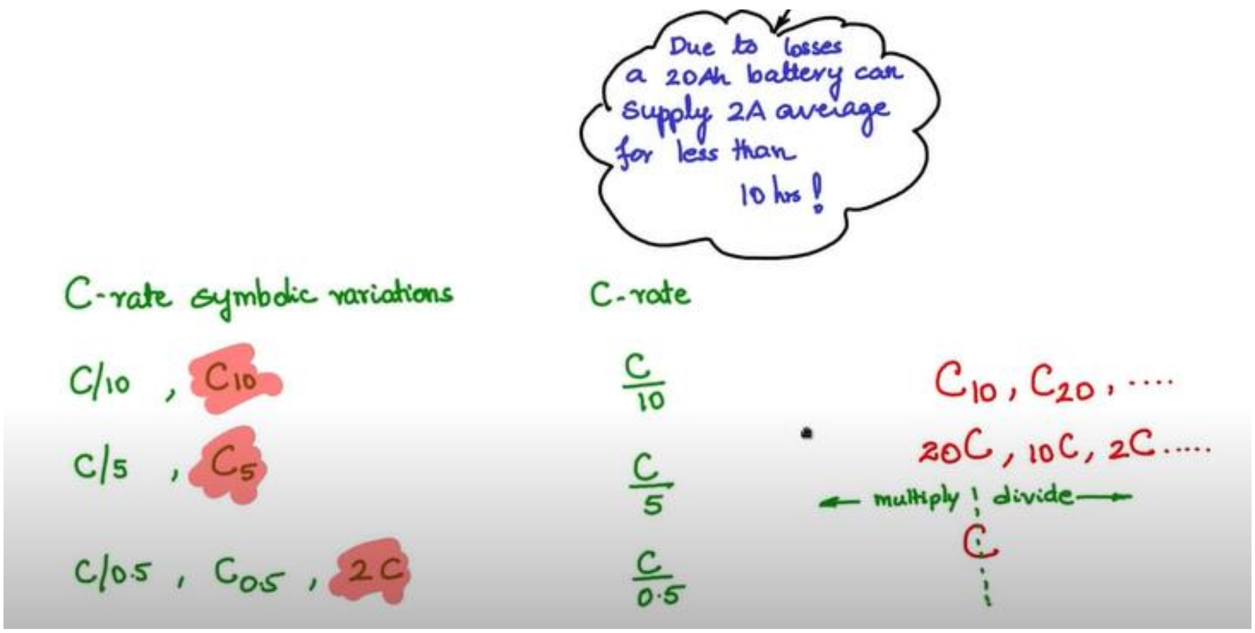
This means a 20 Ah battery can supply 2A average upto 10 hrs

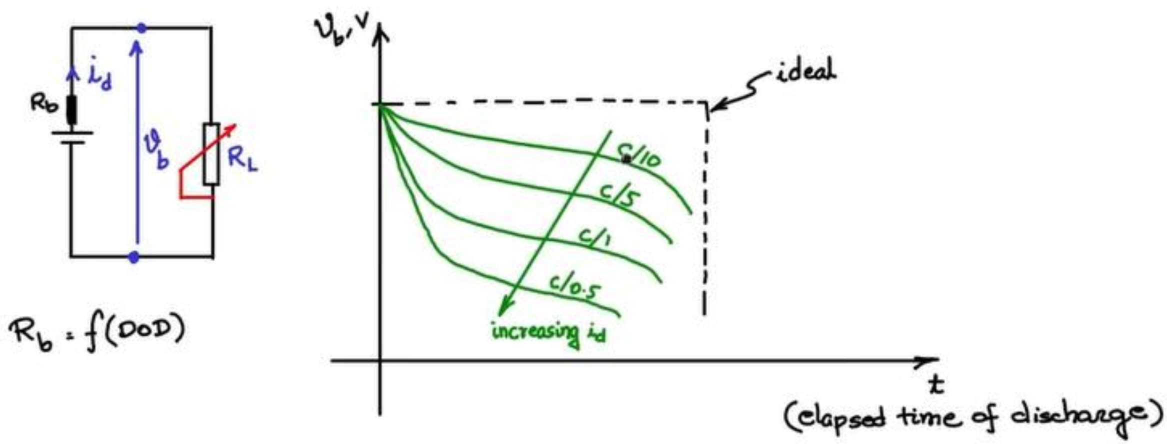
For a 20 Ah battery and 10 hours discharge

$$I_B = \frac{20Ah}{10h} = 2A$$

This means a 20 Ah battery can supply 2A average upto 10 hrs.

Due to losses a 20Ah battery can supply 2A average for less than 10 hrs !





How to buy right battery for our application

Battery discharge in C10 battery

Battery nominal voltage	Battery End voltage
2V	1.75V
4V	3.5V
12V	10.5V
24V	21V

- C10 battery means battery can able to back up 10hours and to reach the battery end voltage

Different C ratings in battery

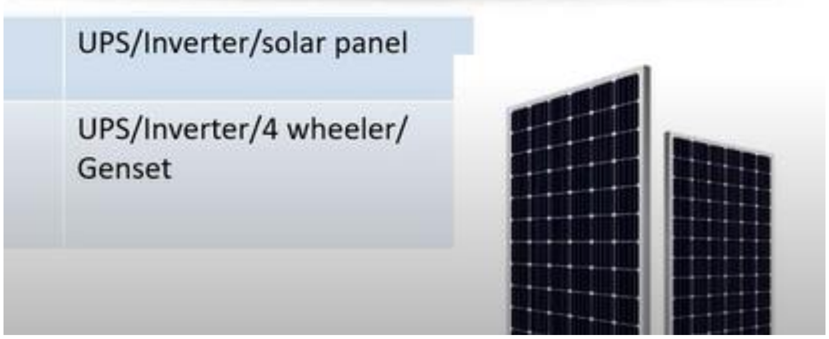
- C3 – 3hour – super fast discharging battery
- C5 – 5 hour – very fast discharging
- C10 – 10hour – fast discharging
- C20 – 20 hour – Normal discharge
- C100 – 100 hour – slow discharging

BATTERY APPLICATION

C rating	Battery Type	Application
C5	Traction battery	Electric traction
C8	Deep cycle battery	E-bike/ golf car
C10	Stationary battery	UPS/Inverter/solar panel
C10	Stationary battery	UPS/Inverter/4 wheeler/ Genset

4th is C20


LUMINOUS


UPS/Inverter/solar panel
UPS/Inverter/4 wheeler/
Genset

Which Battery is Best in Pakistan?

Super capacitor, lithium ion, dry cell

Lead Acid Batteries

Tubular, normal

100A , fast charge, long backup, technology still evolving inverter compatible?

Lithium ion

12/24/48V, 50/100/150A

100A 48V → 1lac 80k to 2lac with 5 years warranty, 10 y life

Expensive

+ Dry battery (not good on high temp, 1 or 1.5 y life, 2-3 y max, expensive, no maintenance)

100A four → 1 lac 25k, 30k/1 battery

DRY CELL 2V

4-5 y life

100A 48 V dry cells (24 cells) → 1lac 50k

Lead Acid Batteries

100A four batteries 40k-50k, not for deep charging and backup

Long back up 100/**150/200A**

20k 100A Tubular battery, 28k 150A, 200A 32k-33k

Four batteries (for 48V) → 80k

3-4 y life

Cheaper

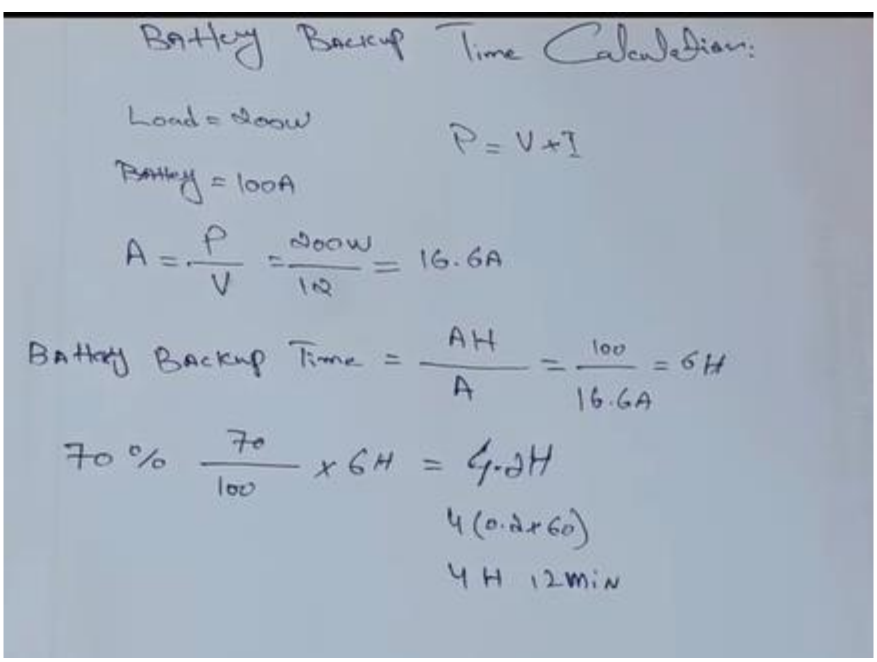
1 y warranty, not good

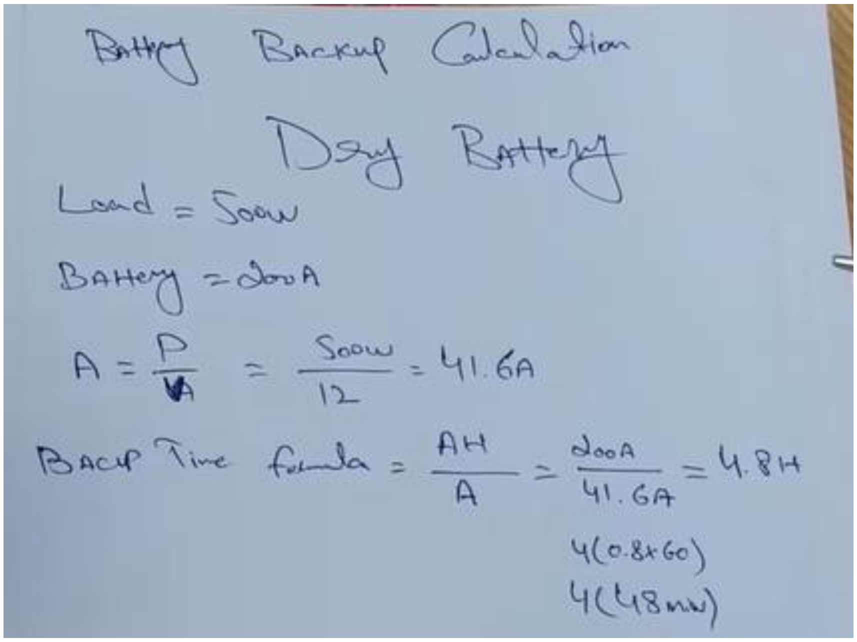
Good imported brands

1 y warranty, good quality

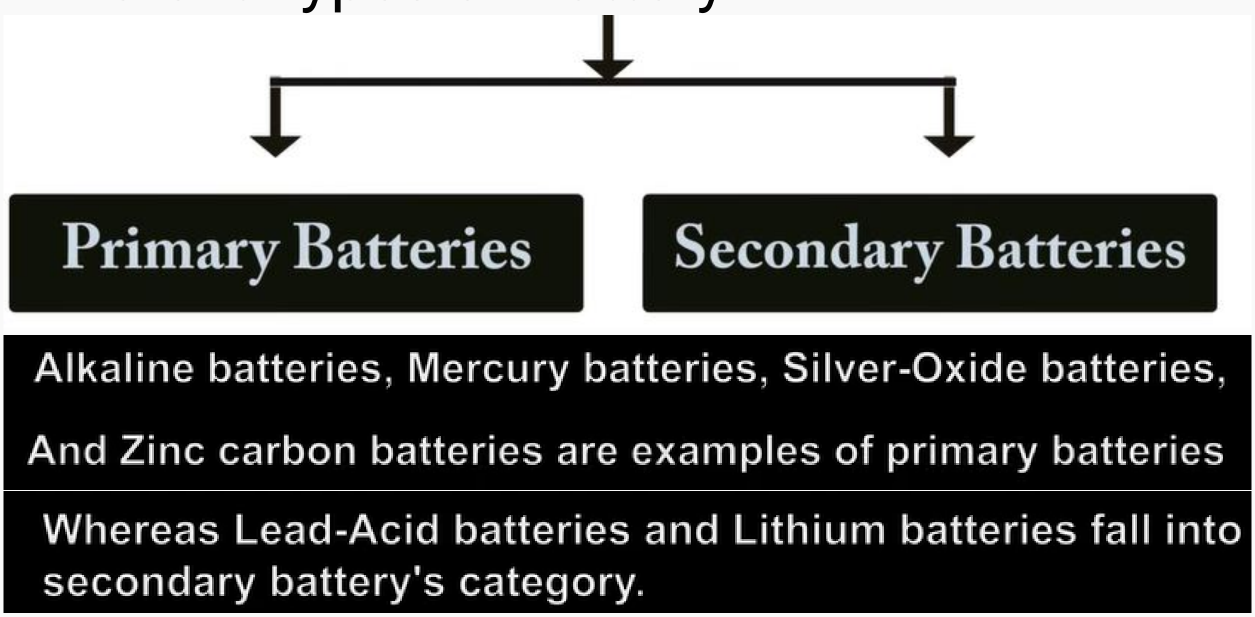
No budget constraint, smooth solution → Lithium ion

Cheaper, longer life, good backup → Tubular batteries, only water change issue





Different Types of Battery



Primary

Carbon Zinc (Heavy Duty):

clocks and remote controls.

Alkaline Cell:

The most commonly used primary cell (household) is the zinc-alkaline manganese dioxide battery.

Lithium Cells:

Lithium Cells:

Their shelf-life can be well above 10-years and they will work at very low temperatures.

Lithium batteries are mainly used in small formats (coins cells up to about AA-size)

because bigger sizes of lithium batteries are a safety concern in consumer applications.

Bigger (i.e. ‘D’) sizes are only used in military applications.

Silver Oxide Cells:

These batteries have a very high energy density but are very expensive due to the high cost of silver.

Therefore silver oxide cells are mainly used in a button cell for watches and calculators.

Zinc Air Cells:

These batteries have become the standard for hearing aid batteries.

They have a very long run time because they store only the anode material inside the cell and use the oxygen from the ambient air as a cathode.

Secondary Battery

Rechargeable Alkaline Batterie:

Secondary alkaline batteries, the lowest cost rechargeable cells,

Have a long shelf life, and are useful for moderate-power applications.

But they are a great consumer's choice as they combine the benefits of the popular alkaline cells with the added benefit of a re-use after recharging.

They have no toxic ingredients and can be disposed of in regular landfills (local regulations permitting).

Nickel-Cadmium:

Secondary Ni-Cd batteries are rugged and reliable.

They exhibit a high power capability, a wide operating temperature range, and a long cycle life, but have a low run-time per charge.

They have a self-discharge rate of approximately 30% per month. They contain about 15% toxic, carcinogenic cadmium and have to be recycled.

Nickel-Metal Hydride:

Secondary Nickel-Metal batteries are an extension of the old fashioned NiCd batteries.

Nickel-Metal batteries provide the same voltage as NiCd batteries but offer at least 30% more capacity.

They exhibit good high current capability and have a long cycle life.

The self-discharge rate is higher than NiCd at approximately 40% per month.

Nickel-Metal cells contain no toxic cadmium,

But they still contain a large amount of nickel oxides and also some cobalt, which are known human carcinogens and should be recycled.

Lithium-Ion:

Secondary Li-Ion batteries are the latest breakthrough in rechargeable batteries.

They are at least 30% lighter in weight than NiMH batteries and provide at least 30% more capacity.

They exhibit good high current capability and have a long cycle life.

The self-discharge rate is better than NiMH at approximately 20% per month. Overheating will damage the batteries and could cause a fire.

Li-Ion cells contain no toxic cadmium, but they still contain either cobalt oxides or nickel oxides, which are known human carcinogens and should be recycled.

Lead-Acid:

Secondary lead-acid batteries are the most popular rechargeable batteries worldwide.

Both the battery product and the manufacturing process are proven, economical, and reliable.

However because they are heavy Lead-Acid batteries are not being used in portable consumer applications.

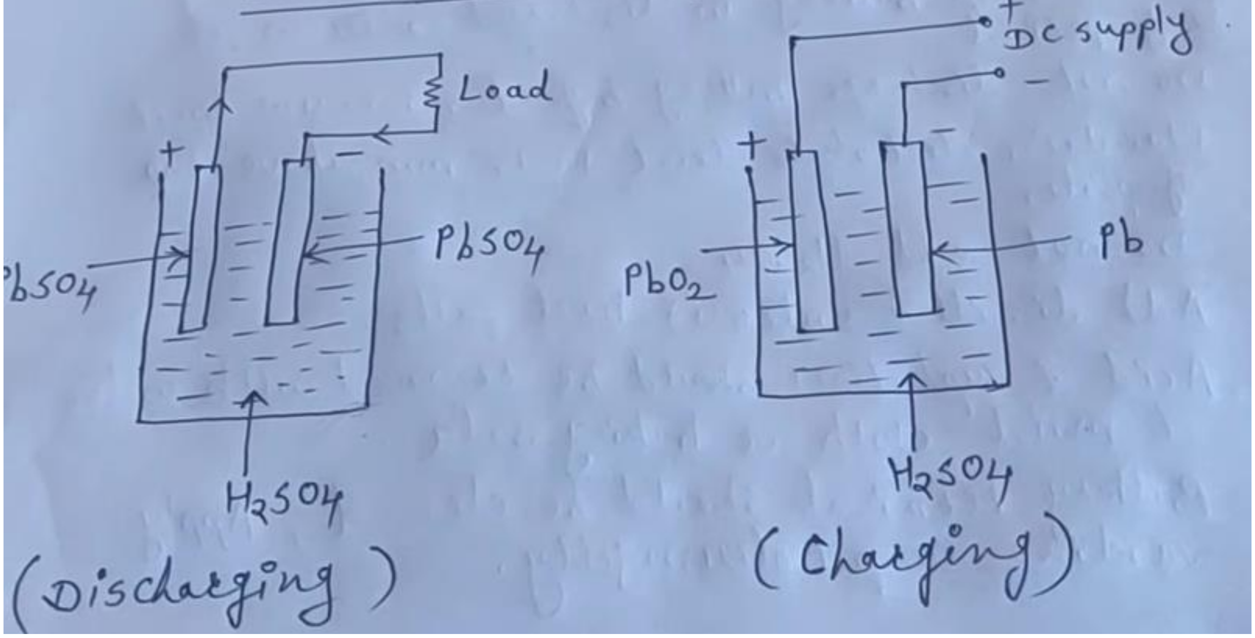
Lead is a toxic, carcinogenic compound and should not enter the regular waste stream.

Recycling of Lead-Acid batteries is the environmental success story of our time approx.

93% of all battery lead is being recycled today in reused in the production of new Lead-Acid batteries.

Charging & Discharging process of Lead acid Battery

Lead Acid Battery



1) Discharging Process

At Anode → $PbO_2 + H_2 + H_2SO_4 \rightarrow PbSO_4 + 2H_2O$

At cathode → $Pb + SO_4 \rightarrow PbSO_4$

Charging Process

Anode → $PbSO_4 + 2H_2O + SO_4 \rightarrow PbO_2 + 2H_2SO_4$

Cathode → $PbSO_4 + H_2 \rightarrow Pb + H_2SO_4$

$PbO_2 + 2H_2SO_4 + Pb$

$$\underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} PbSO_4 + 2H_2O + Pb$$