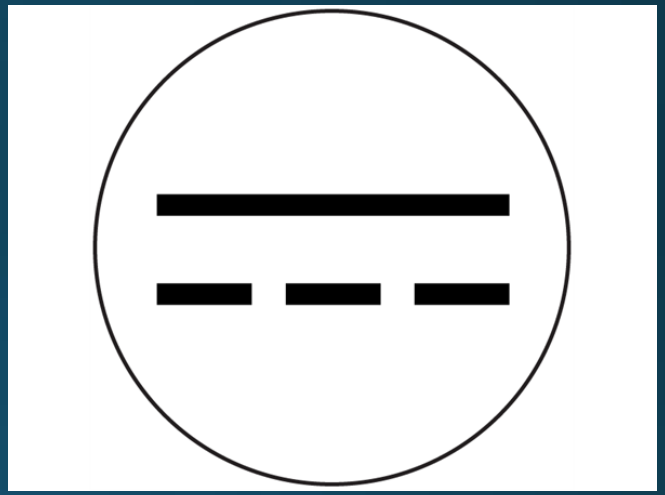
serving our community since 1982

Batteries for Amateur Radio Applications

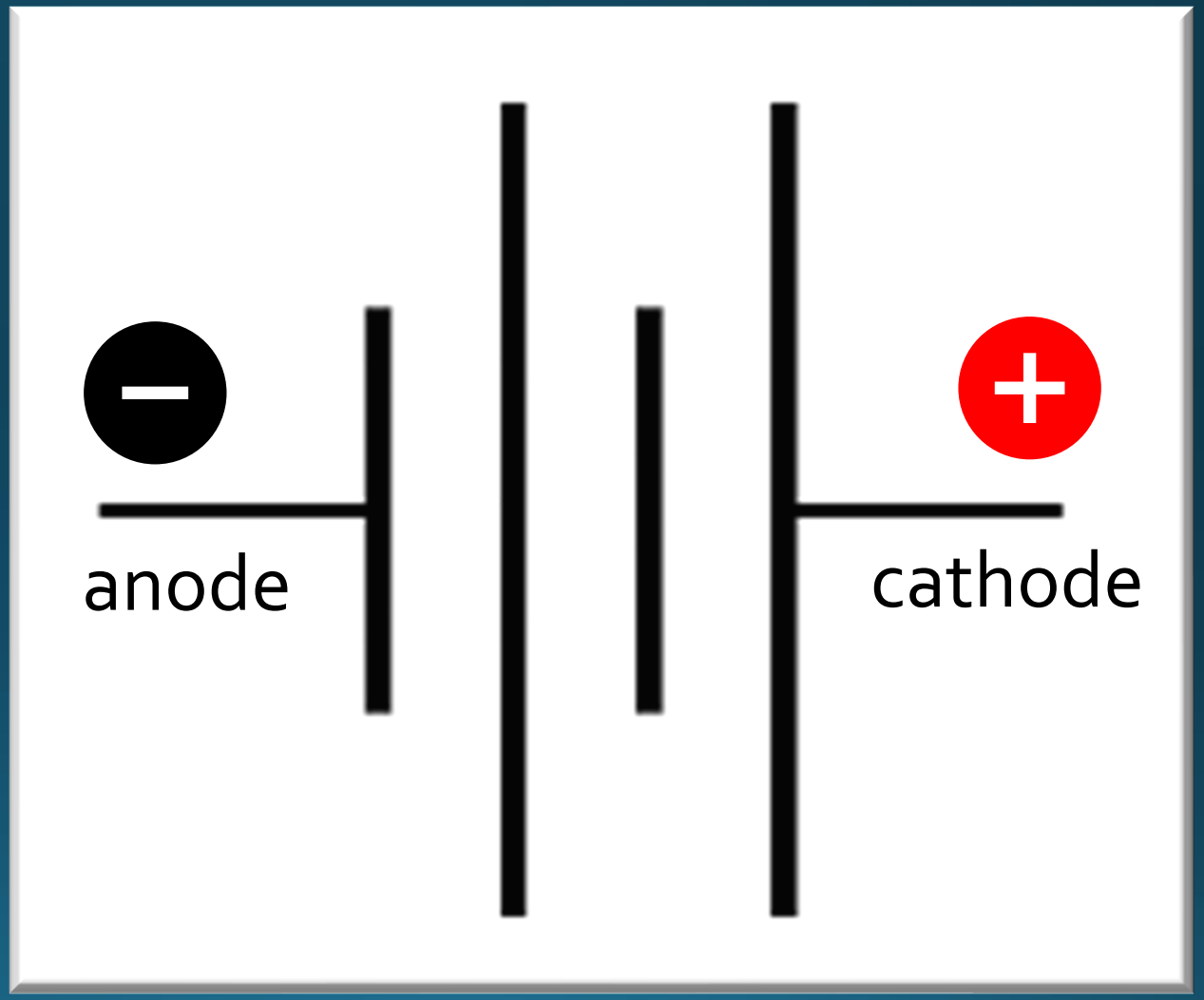
batteries are direct current (DC) power sources

amateur radio equipment is typically designed to operate in a range between 11.7 and 13.8 volts DC



schematic symbol for direct current

battery basics



a cathode is the electrode that current flows from

an anode is the electrode that current flows to

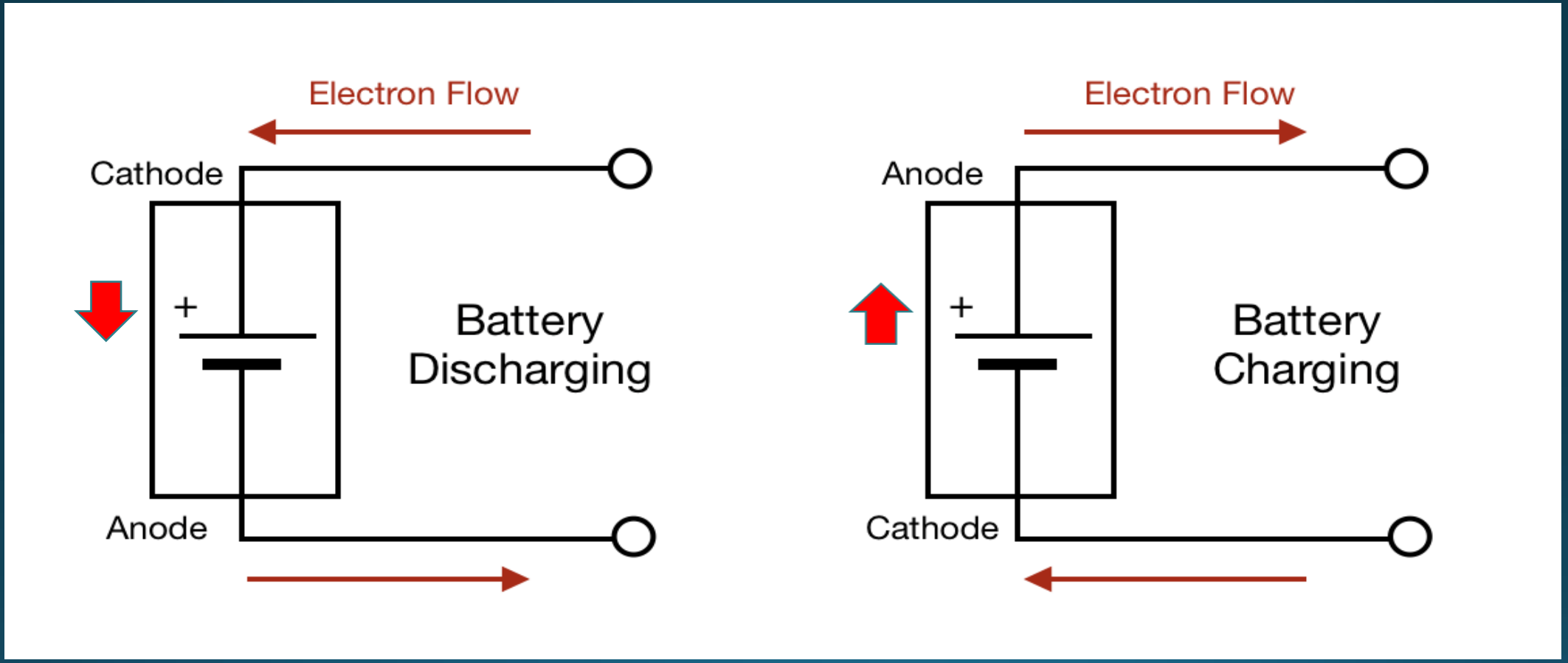
an electrolyte is an electrical conducting chemical capable of transporting an electric charge

traditionally electrolytes were liquids
i.e. **sulfuric acid** as in wet cell batteries

solid materials, i.e. **Lithium tin phosphorous sulfide**,
are now available that allow ions to move
easily through their structures

solid and semi-solid electrolytes are desirable
because they do not readily allowing for
flexible mounting solutions

how current (electrons) flows in a battery



battery types

LiFePO4

lead-acid
(wet cell -SLA)

Lithium Ion

absorbent
glass mat

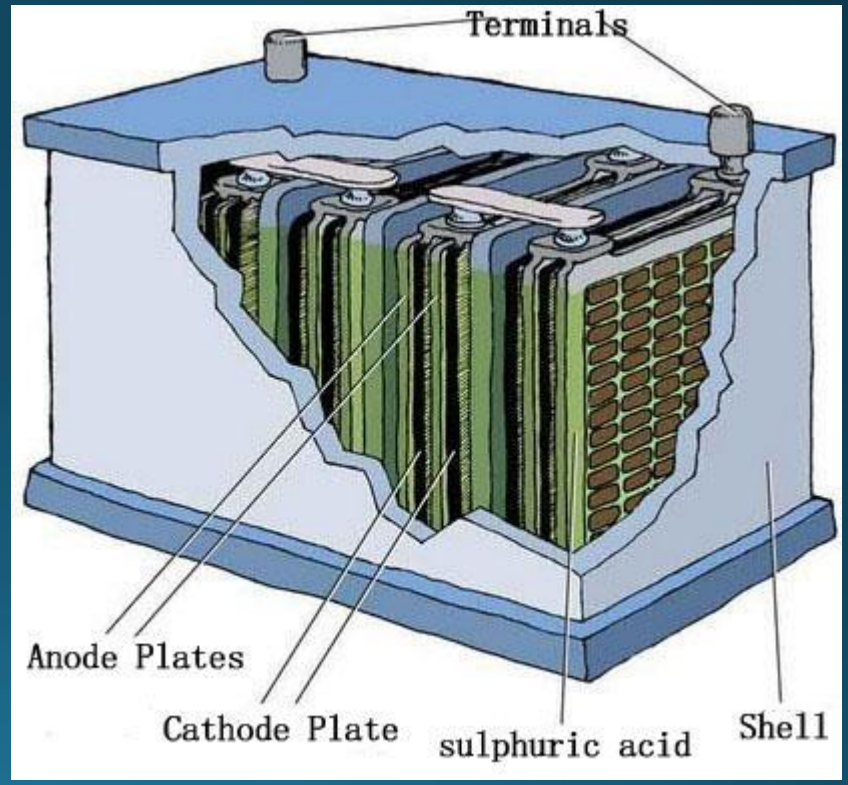
deep-cycle batteries are designed for applications that require deep, repetitive amperage drain over a period of time

starting batteries are designed for short, high amperage drain such as starting a car engine

“marine” type batteries
are designed for
both starting &
deep cycle duties

“flooded” or “wet” cell batteries contain lead plates and a liquid electrolyte (acid)

most common automotive battery type sealed lead acid (SLA)



must be kept upright

shorter life span

may emit explosive gas

does not perform well in extreme cold or heat

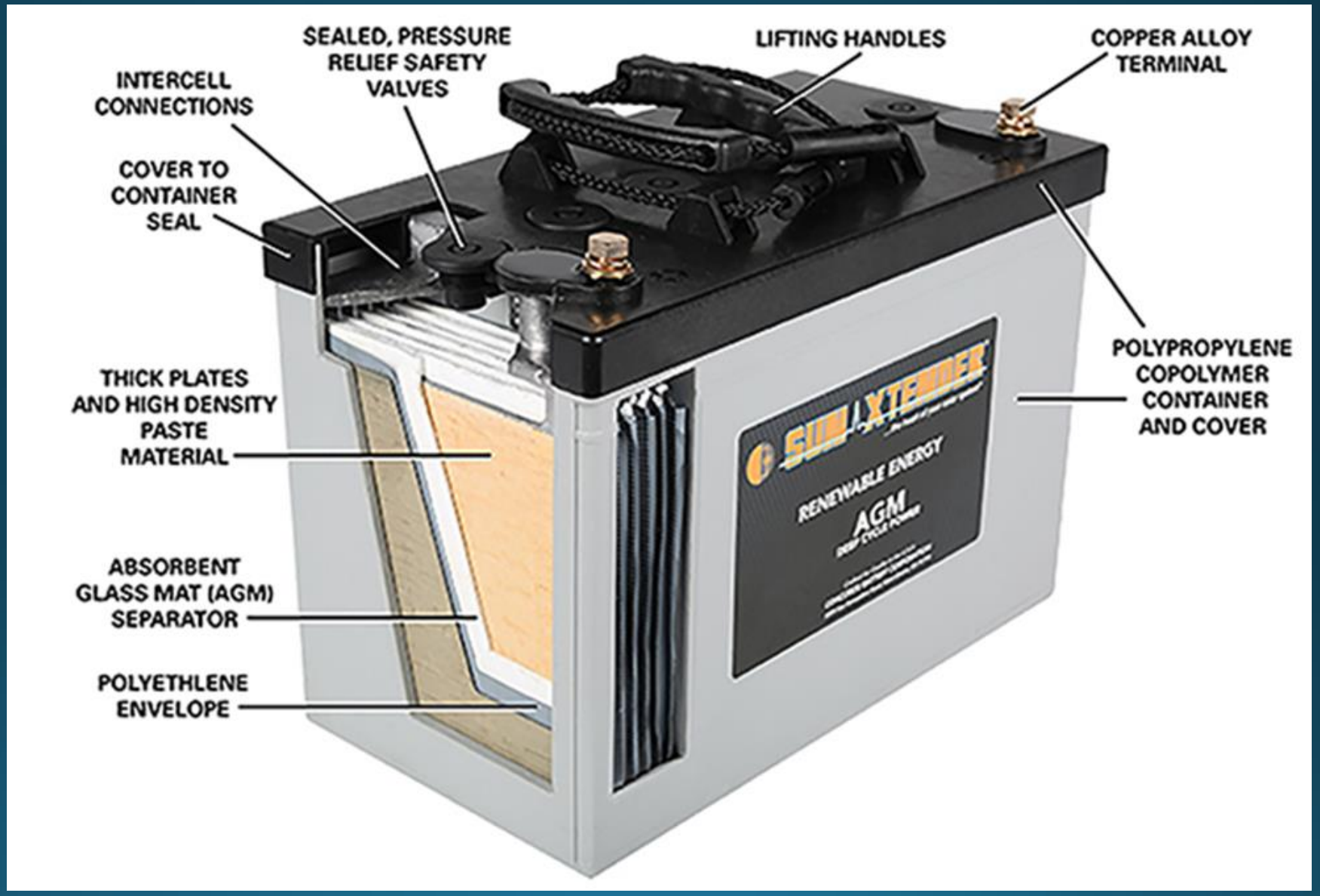
heavy, some require regular maintenance

absorbent glass mat (AGM) battery

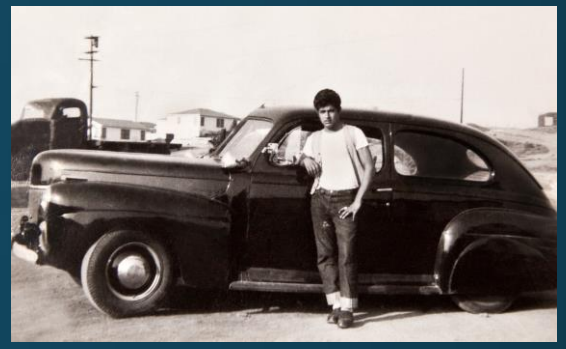
AGM batteries

thin glass fibers soak up the electrolyte (water and sulfuric acid) into thin pillows cushioning the lead plates

unlike the free-flowing liquid inside a “flooded” type battery, the AGM carries its charge in soaked sponges coating the lead plates


SEALED, PRESSURE RELIEF SAFETY VALVES
LIFTING HANDLES
COPPER ALLOY TERMINAL
INTERCELL CONNECTIONS
COVER TO CONTAINER SEAL
THICK PLATES AND HIGH DENSITY PASTE MATERIAL
ABSORBENT GLASS MAT (AGM) SEPARATOR
POLYETHLENE ENVELOPE
POLYPROPYLENE COPOLYMER CONTAINER AND COVER
RENEWABLE ENERGY
AGM

low & slow



a multi-stage, low-amp charger (1-12 amps) is the best choice for charging lead-acid or AGM batteries

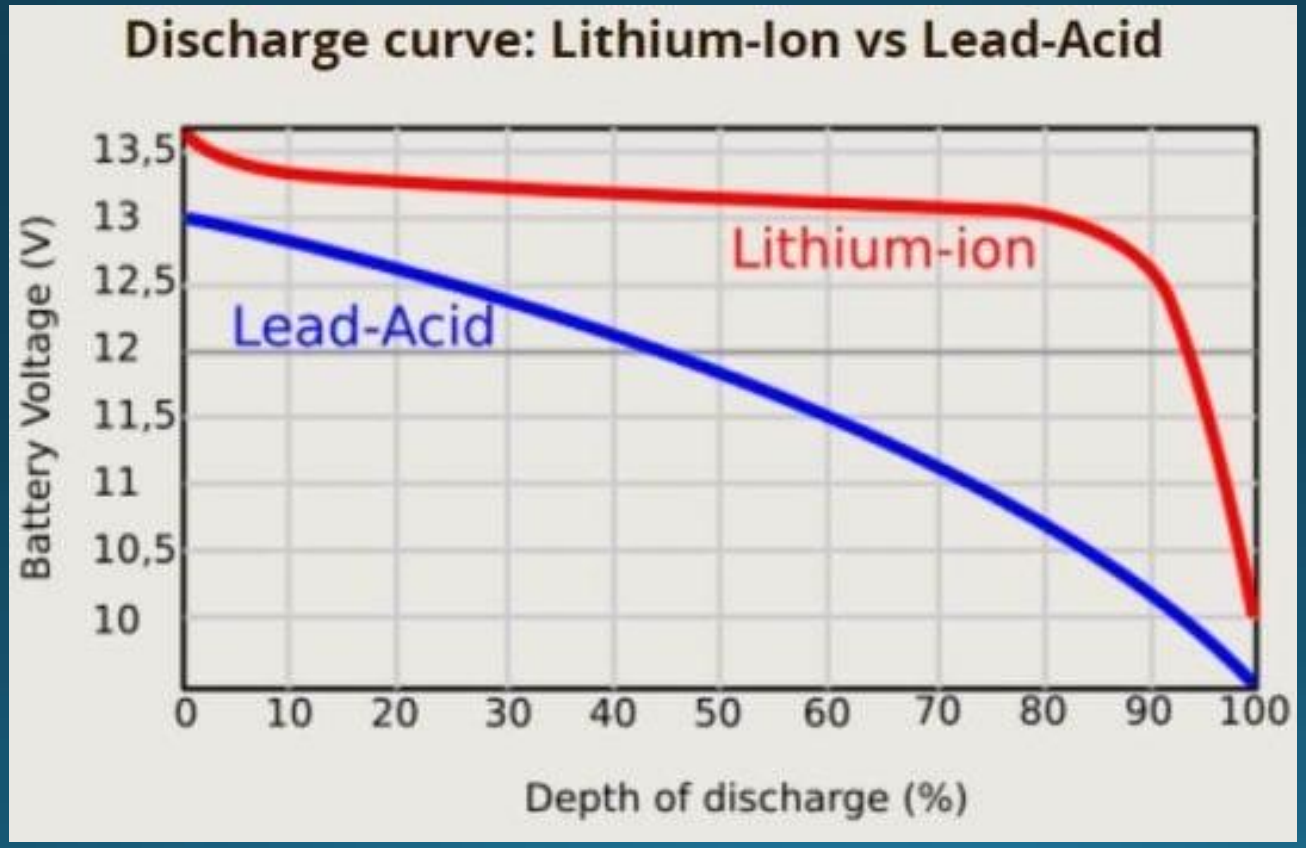
many battery chargers have a setting for AGM

Lithium batteries

Lithium batteries come in a variety of chemical compositions, including lithium iron phosphate ($LiFePO_4$), lithium manganese oxide (LMO), and lithium cobalt oxide ($LiCoO_2$)

in each case the anode is carbon,
but the cathode differs,
consisting of one of the lithium metal oxides
that give each type their respective names

Lithium out-performs all others



Lithium vs Sealed Lead Acid (SLA)

advantages of Lithium-ion (Li-ion)

higher charge density

lighter-weight,
smaller footprint

low self-discharge rate

disadvantages of Li-ion

expensive compared to $LiFePO_4$

fire hazard, toxic to the environment

limited voltages available

limited temperature range
(32°F to 113°F)

Li-ion battery fires are dangerous

damaged or defective Li-ion batteries
can enter an uncontrollable, self-heating
state resulting in the release of gas, and
may cause fire and possible explosion

water may not prevent a battery
from burning and spreading
battery cells are known to explode

Lithium Iron Phosphate – $LiFePO_4$

the cathode is $LiFePO_4$

the anode is typically carbon

the electrolyte is a lithium salt in an organic solvent

advantages of $LiFePO_4$

higher voltage ratings, no memory effect
thermal & chemical stability, low self discharge

tolerates high / low operating temps
(-4°F to as high as 140°F)

built-in safety measures & monitoring
somewhat less harmful to the environment

disadvantages of $LiFePO_4$

low voltage per cell

higher discharge ratio which can cause an imbalance during use

expensive

Safety

LiFePO4 batteries are the
safest Lithium batteries on the market

more stable and less prone to thermal runaway and overheating, issues that have led to Li-ion batteries to having a reputation for a risk of battery fires

water can corrode or damage the internal battery safety devices and cause the battery to overheat, ignite, rupture or leak

a lithium battery should be treated with caution if it has been partially flooded or submerged in water

Lithium batteries should not go into household garbage or recycling bins, they can cause fires during transport or at landfills

damaged Lithium batteries should not be stored in vehicle or a structure and should be taken to recycling or hazardous waste collection points

improper storage or disposal of
Li-ion batteries can be
a safety hazard

an improperly disposed
Li-ion battery caused this fire
in Boise in 2020

Tesla cars use
Lithium-ion batteries

there have been 182
reported instances
of Tesla vehicle
Lithium-ion battery fires

some fire extinguishers types do not work on Li-ion battery fires

Li-ion battery fires are known to unexpectedly re-ignite in minutes, hours and even days after the fire has been put out

ABC or BC class chemical fire extinguishers can be used on Lithium battery fires

a recent development has been the “encapsulating” fire extinguisher

the chemical agent encapsulates the battery cutting off the fire’s oxygen

charging Lithium batteries

Lithium batteries do not require
charging to maintain
voltage if they are partially discharged

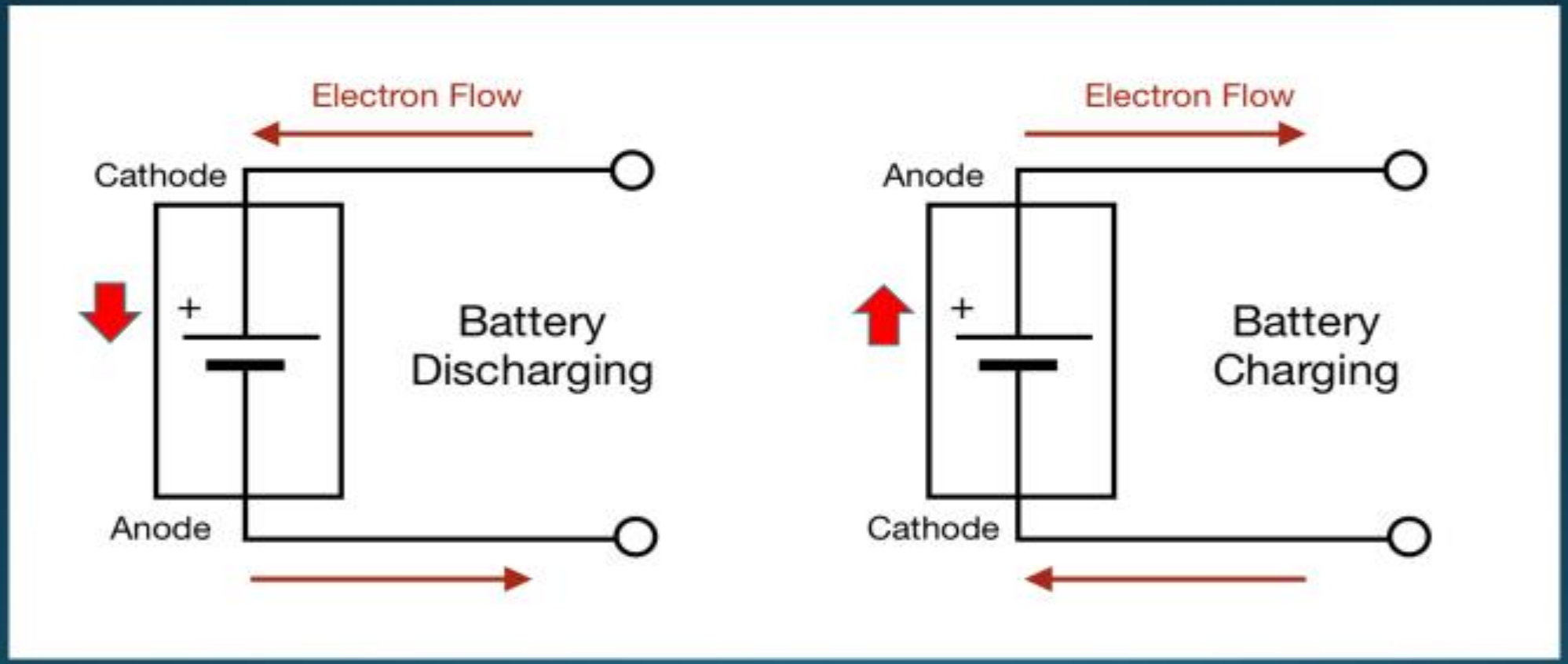
unlike lead-acid batteries, that
when left in a partial
state of charge will sulfate
drastically reducing performance and life

charging Lithium batteries

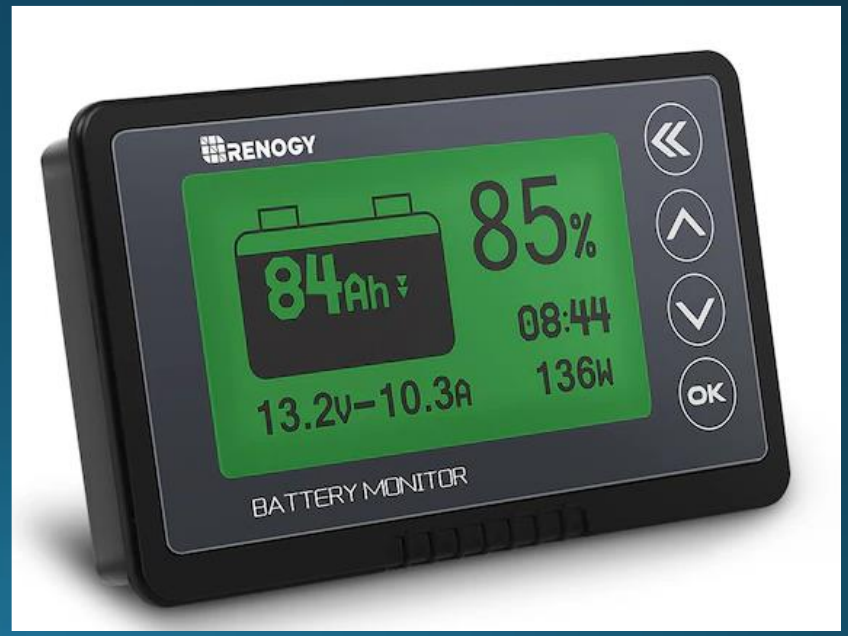
the charging and discharging process are the same for Li-ion and $LiFePO_4$

in both, lithium ions move from the cathode to the anode, the electrons migrate in the opposite direction between cathode to anode creating an electrical current

how current (electrons) flows in a battery



Lithium batteries may come with an internal battery management system that protects the battery from being over-charged



some are Bluetooth equipped allowing monitoring on phones and computers

charging Lithium batteries

Lithium batteries can charge at a much higher current and more efficiently than lead-acid, which means they can be charged faster

charging Lithium batteries

use a Lithium battery charger when charging Li-ion or LiFePO4 batteries

choosing the right capacity battery

battery potential is rated in volts

battery strength is rated in amperes

battery operating time (capacity) is rated in ampere hours (Ah)

how deeply a battery is discharged is rated as Depth of Discharge (DoD)

amp/hour (Ah) is the battery
capacity rating

the standard rating is based on how many
amps you can pull out of the battery
over a 20hr period

for a 100 Ah rated battery you can
draw 5 amps an hour
over a 20hr period (5 x 20 = 100)

it is important to know that the total
time of discharge and load applied is
not a linear relationship

as your load increases,
your realized capacity decreases

if you discharged 100 Ah battery
at a 100-amp load, you
would realize a capacity rating of about
64 Ah of runtime

calculating Ah requirement

transmitter power level

manufacture's power usage specs

mode – cw ssb, fm & digital

TX & RX time

other loads

a rule of thumb for current drawn by a transceiver working on a 12v supply is

1A per 5w RF output

100w RF output requires
20 amps of power

what battery amp hour rating do we need?

- our radio draws 20A on TX and 2A on RX
- we will be operating total of 10 hrs
- we do not want our battery to go below 50% of DoD (Depth of Discharge)
- we are not operating any ancillary devices from the battery

for those who prefer the math

X = % of time RX

Y = % of time TX

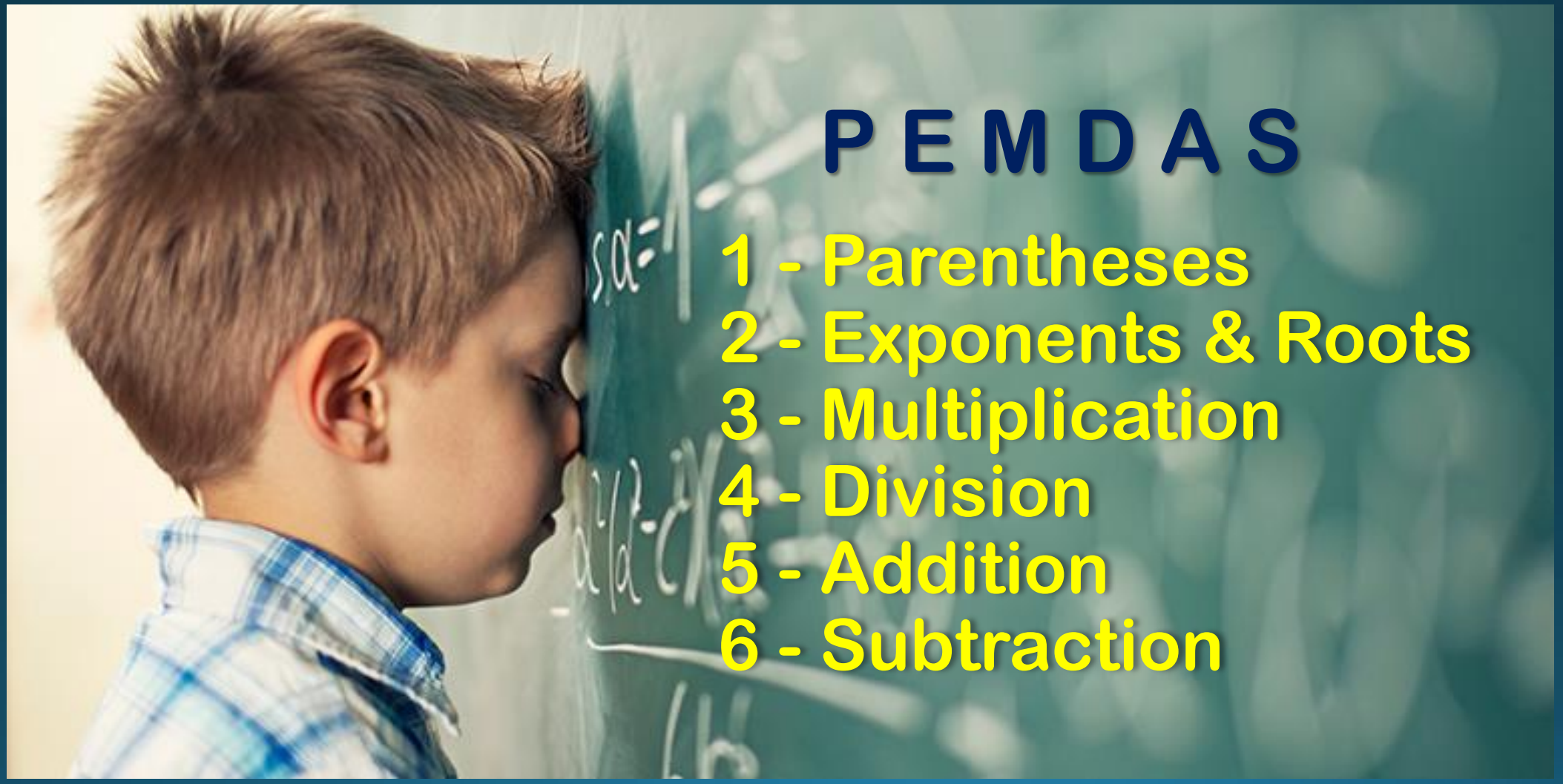
Z = total hours of operation

a = load in amps RX

b = load in amps TX

$$((x * a) + (y * b)) * z = Ah$$

((x * a) + (y * b)) * z = Ah


P E M D A S
1 - Parentheses
2 - Exponents & Roots
3 - Multiplication
4 - Division
5 - Addition
6 - Subtraction

X = 80% of time RX

Y = 20% of time TX

Z = 10 total hours

a = 2 amps RX

b = 20 amps TX

((.80 * 2) + (20 * .20)) * 10 = Ah

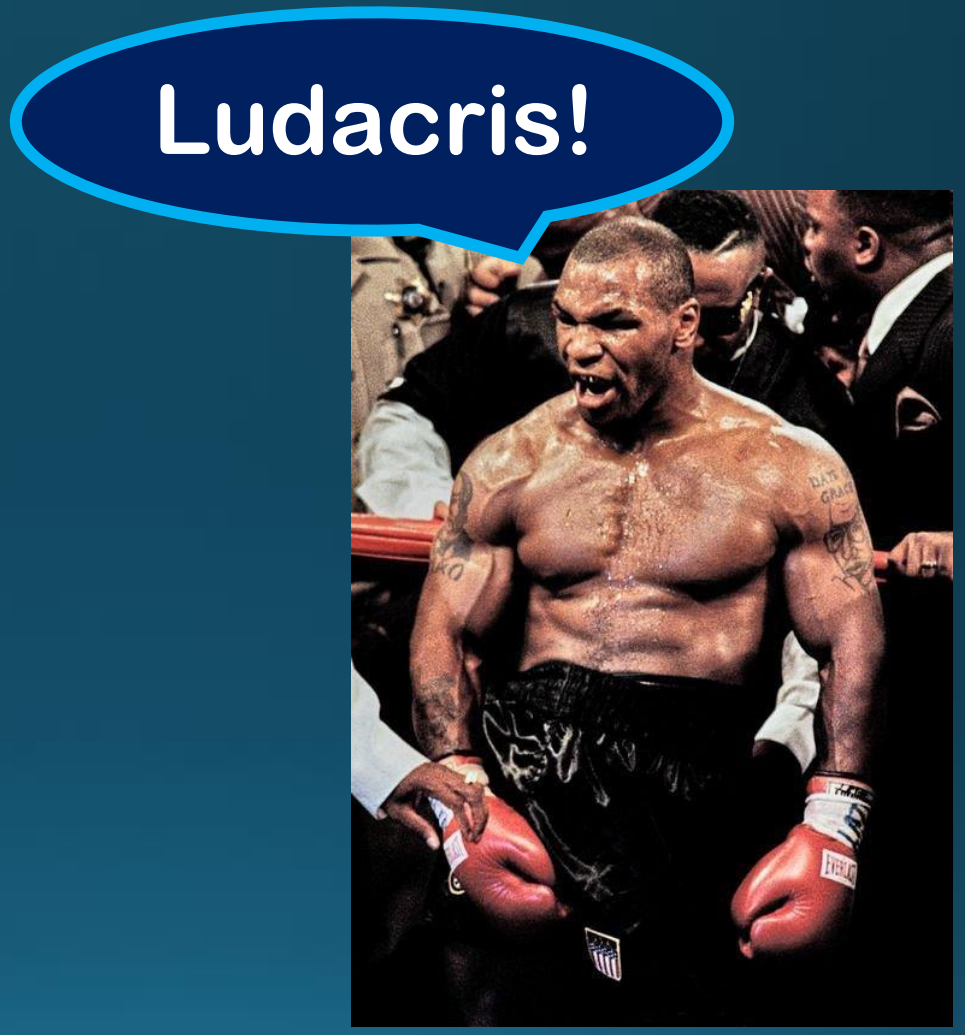
1.6 + 4 * 10 = 56 Ah

operating in the real world

modulated modes, on/off keying and operator downtime will reduce overall power consumption

if its feasible (and affordable), double the calculated Ah rating of the battery to create a reserve

we need a 112 amp hour battery ?



no, it's not because……

the previous calculation is theoretical, reflecting an efficient battery in good shape and starting at a 100% charge and…

….the further a lithium battery has been discharged, the more rapid the discharge rate

if you are not into doing the math…

…..you can buy one of these for $19 on eBay or Amazon and get the same answers

making the battery choice

SLA

low priced
heavy
low DoD *
low charge count
limited mounting
emit explosive gas
charge memory

Li-ion

lighter than “wet”
long charge life
fire risk
not eco friendly
expensive
travel limitations
no memory
high DoD

$LiFePO_4$

expensive
light weight
high charge count
maintains voltage
eco friendly
no memory
built-in monitor
high DoD

* DoD Depth of Discharge

ciarc.org

centralidarc@gmail.com